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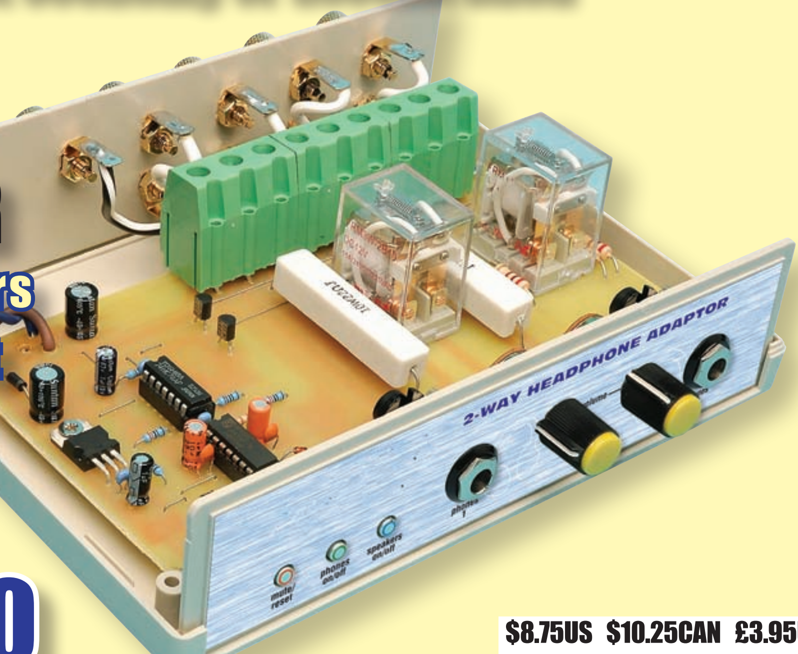

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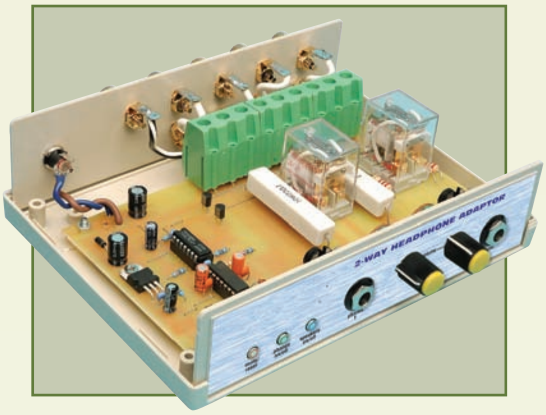

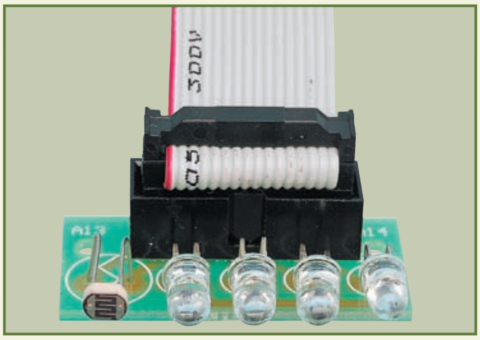

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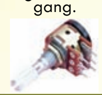

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What would you like to see in EPE?

If you are reading this, then the chances are good that you are practical person; someone who likes to understand the technical world around them, and who especially wants to get involved with electronic technology at a hands-on level. We certainly provide that hands-on aspect with our projects, but we also work hard to provide you with an understanding of design and theory.

In other words, we ensure EPE is a well-rounded magazine. It would be easy just to publish projects and let you the reader 'simply' follow the instructions, which, with care and a few troubleshooting tips, is more than likely to result in a successful build. However, that would miss the point of EPE, which is about enjoying electronics at a deeper level, and the very best way to do that is to really understand what is going on in a circuit. If you do appreciate the thinking behind a circuit's design, then not only can you improve or customise it to your own requirements, but also start on the rewarding process of designing and building your own original projects.

From 'Circuit Surgery', Practically Speaking' and 'Pic n' Mix' to our longer 'Teach-In' series, we aim to cover the full spectrum of contemporary electronic design – and we aim to do that for both beginners and those of you who are more experienced. We have a pretty good idea of what you enjoy; however, there is always room for improvement. In a discipline as large as electronics, it would be extraordinary if there weren't dozens of aspects of this versatile technology that we have neglected and which you would like too see covered. I briefly mentioned Nixie tubes last year, and knowledgeable readers sent in letters, emails, hyperlinks and just recently a project.

That was a splendid (but not untypical) response, and the point of this Editorial is to remind you that we welcome your ideas for content – not just projects, but also explanations of design techniques, from analogue electronics to PIC software debugging.

So, do write in and let us know what you would like to see in your magazine.

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We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

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NEWS

A roundup of the latest Everyday News from the world of electronics

LED TV projector technology **By Barry Fox**

Demonstrations of competing LED projectors highlight the compromises designers now face when using the new solid-state light-emitting technology instead of conventional UHP, or ultra high performance, mercury arc lamps.

The UHP system was developed by Philips in 1995 and generates very high light output from a small lamp. But life is limited to a few thousand hours at best, with many projectors coming with only a three month warranty on the lamp. Plus, mercury content makes disposal of dead lamps an eco challenge.

UHP lamps can take up to an hour after switch on to give true colour, and cannot be quickly switched on and off. LED lamps last around 70,000 hours, are mercury-free for easy disposal and can be switched on and off instantly. LEDs convert electricity to light more efficiently and achieve steady colour state in 10 seconds, with a wider range of colours. No mechanical iris is needed for near infinite contrast ratio, and because separate red, green and blue LEDs are used, there is no DLP colour wheel, so no risk of 'rainbow effect' – the colour strobing which viewers may see if they move their head rapidly while watching the projected picture.

But LEDs are expensive, light output is less than for UHP lamps, and extreme cooling is needed if the projector is to fill a large screen.

Runco's Holger Graeff, claims its new QuantumColor 1080p single-chip LED projector, the Q-750 (costing around £18,000), uses 70% less power than lamp-based projection. Power consumption varies up to 250W, with 140W for typical use.

"Lampless LED is the future of video projection" says Planar CEO Gerry Perkel.

"An LED lampless light source is clearly the next step in front projection" says Joel Silver, founder and president of the Imaging Science Foundation.

Runco recommends a screen width of 72 inches to 92 inches, with a maximum of 108 inches. Graeff told us: "LED is not perfect yet. LED technology is developing. It's a beginning. And if you are happy with 100 inches in a dark room you can be happy with LED. The colours are so bright you don't notice that the picture is not so bright."

Room lights were completely dimmed to show clips from Cars, US football coverage, Dark Knight and Elton John in concert on a 92inch screen – with good results.

Different approach

SIM2, the Italian manufacturer, has adopted a different approach with the 1080p MICO 50 LED projector (£15,000). Whereas Runco uses conventional fan air cooling for its LEDs, SIM2 uses liquid cooling to increase power consumption to 370W, while still claiming a lifetime 'well above 100,000 hours'.

Demonstrating the SIM2 LED projector on the large screen of the British Film Institute's screening room in London, specialist journalists at first thought UK Managing Director Alan Roser was joking when he explained why the single-chip HD projector was as big as a carry-on suitcase – "it needs water cool plumbing", he said.

But after an impressive demonstration of *Star Trek*, he took off the projector lid and showed he wasn't jesting. The three discrete LEDs (red, green and blue) generate so much heat that a liquid cooling system, which looks just like a miniature car radiator with pumps, pipes and fans, is needed.

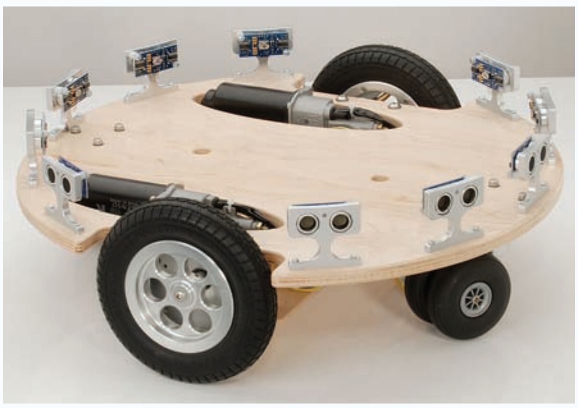
Footnote

At the Runco demonstration in a London bar a few days later, Holger Graeff declined our request to remove the top of the Runco projector; he attributed the large size of the unit – similar to the SIM2 projector – to the large optics. The air coming from the side vents was just pleasantly warm, with no evidence of high temperatures inside the box.

Robot Base Kit

A Robot Base Kit has been introduced by Parallax. This is a plywood platform kit for the 12V Motor Mount and Wheel Kit (#27971) and the Caster Wheel Kit (#28971). This kit allows users to build a nearly complete robot and then add on their choice of processor and sensors (sold separately).

Also from Parallax is the Programming & Customizing the Multicore Propeller Microcontroller: Official Guide. *The book begins with an introduction to the Propeller chip's architecture and Spin programming language, debugging techniques, and sensor interfacing.*



The remainder of the book introduces eight diverse and powerful applications, ending with a speech synthesis demonstration written by the Propeller chip's inventor, Chip Gracey. Numerous illustrations and example programs accompany each application. Example source code and other related resources are available for free download from ftp://ftp.propeller-chip.com/PCMProp.

More information is available from ***www.Parallax.com***

Touchscreen teaching

COMPUTER supplier ASUS wanted to explore the potential of the effective use and deployment of some of the Eee family of touchscreen computers within the infant and primary school environments. And whether or not this would have any impact on how younger children play and learn within the classroom.

The partner schools selected for the trial were Hobbs Hill Primary and Dulwich Village Church of England Infants School (DVIS). Hobbs Hill is the larger of the two, with 476 pupils from reception (age 4) to year 6 (age 11). DVIS has 270 pupils, from reception to year 2 (age 7).

Each school delivers its ICT (Information and Communication Technologies) curriculum via computers inside classrooms and dedicated computer suites. All teaching staff are involved in ICT teaching to some extent, and exploring new learning opportunities through ICT is seen as an important area. As Graham King, ICT coordinator for Hobbs Hill Primary, explains: "The challenge for us is to find more innovative ways of using ICT, rather than just create more impressive PowerPoint presentations."

ASUS Eee Top PCs were installed in Dulwich Village Infants' reception (ages four to five), year 1 (ages five to six) and year 2 (ages six to seven) classes. Eee PCs were also placed into one reception class. ASUS Eee PCs were provided for every pupil in one year 5 (ages 10 to 11) class at Hobbs Hill Primary, along with one Eee Top PC. A second Eee Top PC was also used in a Nursery class.

Much to Dulwich Village Infants' and Hobbs Hill Primary's delight, the ASUS Eee Top PCs proved to be a huge hit. Young pupils were more at ease with using the Eee Top PC's touchscreen than a traditional mouse, and this proved highly motivating.

"The Eee Tops were so popular that children were eager to get into class early to use them", says Sheila Kirrane, ICT coordinator at Dulwich Village Infants. "The children seemed to be more confident when using them and not afraid to make mistakes, as they were able to rectify them without adult intervention."

Hobbs Hill's nursery also liked the Eee Top PC's unique approach. "I can see a lot of potential for having these computers in classes where mouse control is more difficult", says Miss King, Hobbs Hill's Assistant Nursery Manager. "Playing maths games or interacting with particular websites in this way would be a great advantage."

The Eee Top PC's touchscreen also offered one unexpected advantage, as Hobbs Hill year 6 pupil Laurie, age 6, points out: "Less arguing about the mouse when working in pairs!"

Although initially sceptical about netbooks, Hobbs Hill Primary soon saw the appeal of the ASUS Eee PCs. Graham King, ICT coordinator for Hobbs Hill Primary, explains: "The Eee PCs were easy to handle and were seen as potentially becoming a tool just like a calculator. I could see these being used on school journeys when we stay at a youth hostel."

The ease with which very young children could carry the lightweight Eee PCs also meant that they weren't confined to use in just one part of the classroom.

"The fact that they are so manageable and robust was a big plus, and they can easily be used outside or transported to another part of the room", says Sheila Kirrane. "This encouraged real collaboration and plenty of 'on task' discussion."

Both schools were taken aback by the extremely positive reactions of their pupils to the ASUS computers and Dulwich Village was particularly smitten with the Eee Top PC.

"The Eee Top PCs gave greater independence to our learners and they became more familiar with touchscreen computers. The children's' enthusiasm seemed to be reignited!" says Sheila Kirrane.

Ben, age 5, makes his appreciation of the ASUS Eee Top PC very clear: "I love this computer! It is easy to switch on and I don't need a teacher to help me."

It was a similar story at Hobbs Hill. Graham King says: "Perhaps the biggest impact was the enthusiasm with which the children responded to them. They saw them very much as something they could take ownership of."

You can follow ASUS on Twitter: **http://www.twitter.com/asusuk**

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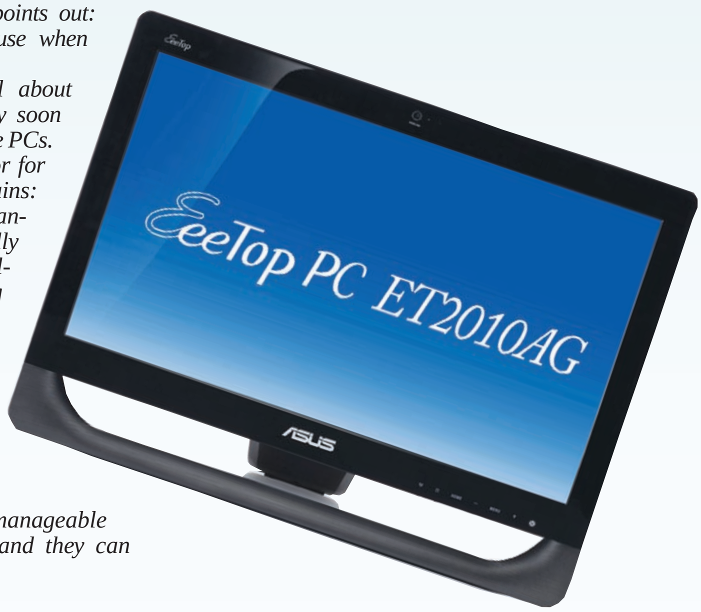


USB flash drive kill pill

Kill Pill from Swedish company Cryptzone (**www.cryptzone.com**) makes it possible for a user or administrator to, at any time through the Internet, lock or wipe the contents on a lost or stolen USB flash drive wherever it is in the world.

Protecting USB flash drives has become a high priority for many companies. With the new version of Secured eUSB, Cryptzone can offer a new level of security which meets the current requirements for existing and upcoming information security laws throughout the world.

Besides the Kill Pill feature, Secured eUSB contains a long list of new functionality and improvements in order to meet the growing demand for high security for businesses today. Among the new features are 'Synchronized Login' to Microsoft Active Directory and DCR – Data Content Reporting.

Each USB flash drive has built-in intelligence to report in real-time,when the flash drive was created, what files are on the flash drive, where the files came from (path and computer), what was done with the files and, most importantly, what user accessed the drive and what did he/she do with the files. Additionally, the reports include an asset inventory listing of Active Directory members that indicates exactly the number of USB flash drives owned, brand/model of the drive, when it was created and much more.

The Secured eUSB solution can encrypt any brand/model of USB flash drive and even deal with flash drives that already contain data.

By JIM ROWE

High-accuracy Digital LC Meter

Here's a handy piece of test gear you can build for yourself – a Digital LC Meter for measuring inductance and capacitance over a wide range. It's based on an ingenious measurement technique, delivers surprising accuracy and is easy to build.

MANY modern DMM's (digital multimeters) have capacitance measuring ranges, especially the up-market models. So it's not hard to measure the value of capacitors, as long as their value is more than about 50pF or so.

Below that level, DMMs are not very useful for capacitance measurements. Dedicated digital capacitance meters are available, of course, and they generally measure down to a few pF or so. But if you want to measure things like stray capacitance, they too are of limited use.

It's even worse when it comes to measuring inductors. Very few DMMs have the ability to measure inductance, so in many cases you have to use either an old-type inductance bridge or a 'Q' meter. Both of these are basically analogue instruments, and don't offer either high resolution or particularly high accuracy.

Micro solution

It's different for professionals, who for the last 20 years or so have been able to use digital *LCR* meters. These allow you to measure almost any passive component quickly and automatically, often measuring not just their primary parameter (like inductance or capacitance) but one or more secondary parameters as well. However, many of these instruments carry a hefty price tag, keeping them well out of reach for many of us.

Fortunately, thanks to microcontroller technology, that situation has changed somewhat in the last few years, with much more affordable digital instruments now becoming available. These include both commercial and DIY instruments, along with the unit described here.

Main features

As shown in the photographs, our new Digital LC Meter is very compact. It's easy to build, has an LCD readout and fits snugly inside a UB3-size utility box. It won't break the bank either – we estimate that you should be able to build it for less than £40.

Despite its modest cost, it offers automatic direct digital measurement over a wide range for both capacitance (*C*) and inductance (*L*) with 4-digit resolution. In fact, it measures capacitance from just 0.1pF up to 800nF and inductance from 10nH to 70mH.

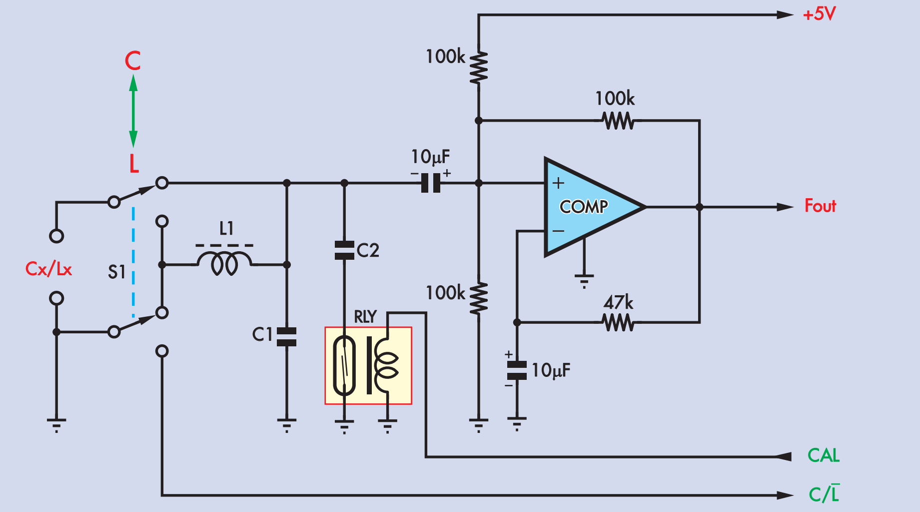


Fig.1: the circuit uses a wide-range test oscillator, the frequency of which varies when an unknown inductor (Lx) or capacitor (Cx) is connected. This oscillator is in turn monitored using a microcontroller which accurately calibrates the unit and measures the change in oscillator frequency. The microcontroller then calculates the unknown component's inductance or capacitance and displays the result on an LCD.

HOW IT WORKS: THE EQUATIONS

(A) In calibration mode

(1) With just L1 and C1: $F1 = \dfrac{1}{2.\pi.\sqrt{L1.C1}}$

(2) With C2 added to C1: $F2 = \dfrac{1}{2.\pi.\sqrt{L1.(C1+C2)}}$

(3) From (1) and (2), we can find C1:

$$C1 = \frac{F2^2}{(F1^2 - F2^2)} \bullet C2$$

(4) Also from (1) and (2), we can find L1:

$$L1 = \frac{1}{4.\pi^2.F1^2.C1}$$

(B) In measurement mode

(5) When Cx is connected: $F3 = \dfrac{1}{2.\pi.\sqrt{L1.(C1+Cx)}}$

so $Cx = C1 \bullet \left(\dfrac{F1^2}{F3^2} - 1\right)$

(6) Or when Lx is connected:

$$F3 = \frac{1}{2.\pi.\sqrt{(L1+Lx).C1}}$$

so $Lx = L1 \bullet \left(\dfrac{F1^2}{F3^2} - 1\right)$

NOTE: F2 & F3 should always be lower than F1

Measurement accuracy is also surprisingly good, at better than ±1% of reading.

It operates from 9V to 12V DC, drawing an average current of less than 20mA. This means that it can be powered from either a 9V alkaline battery inside the case, or from an external plugpack supply.

How it works

The meter's impressive performance depends on an ingenious measurement technique which was developed about 12 years ago by Neil Hecht, of Washington state in the US. It uses a wide-range test oscillator whose frequency is varied by connecting the unknown inductor or capacitor you're measuring. The resulting change in frequency is measured by a microcontroller, which then calculates the component's value and displays it directly on an LCD readout.

So there are basically only two key parts in the meter: (1) the test oscillator itself and (2) the microcontroller which measures its frequency (with and without the component being measured) and calculates the component's value.

To achieve reliable oscillation over a wide frequency range, the test oscillator is based on an analogue comparator with positive feedback around it – see Fig.1. This configuration has a natural inclination to oscillate because of the very high gain between the comparator's input and output.

When power (+5V) is first applied, the comparator's non-inverting (+) input is held at half the supply voltage (+2.5V) by a bias divider formed by two 100kΩ resistors. However, the voltage at the inverting input is initially zero because the 10µF capacitor at this input needs time to charge via the 47kΩ feedback resistor. So, with its non-inverting input much more positive than its inverting input, the comparator initially switches its output high (ie, to +5V).

Once it does so, the 10µF capacitor on the inverting input begins charging via the 47kΩ resistor and so the voltage at this input rises exponentially. As soon as it rises slightly above the +2.5V level, the comparator's output suddenly switches low.

This low voltage is fed back to the comparator's non-inverting input via a 100kΩ feedback resistor. It is also coupled through the 10µF input capacitor to a tuned circuit formed by inductor L1 and capacitor C1. This makes the tuned circuit 'ring' at its resonant frequency.

Oscillation

As a result, the comparator and the tuned circuit now function as an oscillator at that resonant frequency. In effect, the comparator effectively functions as a 'negative resistance' across the tuned circuit, to cancel its losses and maintain oscillation.

Once this oscillation is established, a square wave of the same frequency appears at the comparator's output and it is this frequency (F_{out}) that is measured by the microcontroller. In practice, before anything else is connected into the circuit, F_{out} simply corresponds to the resonant frequency of L1, C1 and any stray capacitance that may be associated with them.

When power is first applied to the meter, the microcontroller measures

Specifications

- **Inductance Range:** from about 10nH to over 70mH (4-digit resolution)
- **Capacitance Range**: from about 0.1pF to over 800nF (4-digit resolution)
- **Range Selection:** automatic (capacitors must be non-polarised types)
- **Sampling Rate:** approximately five measurements per second
- **Expected Accuracy:** better than ±1% of reading, ±0.1pF or ±10nH
- **Power Supply:** 9V to 12V DC at less than 20mA (non-backlit LCD module). Can be operated from an internal 9V battery or an external plugpack.

Parts List – High-accuracy Digital LC Meter

*1 PC board, code 745 (Main), size 125 × 58mm
*1 PC board, code 746 (Adpt.), size 36 × 16mm
*1 PC board, code 747 (Bar), size 41 × 21mm
1 UB3-size box, 130 × 68 × 44mm
1 16×2 LCD module (Jaycar QP-5515 or QP-5516 or similar – see panel)
1 5V 10mA DIL reed relay (Jaycar SY-4030)
1 100μH RF inductor (L1)
1 4.0MHz crystal, HC-49U
1 DPDT subminiature slider switch (S1)
1 SPST momentary contact pushbutton switch (S2)
1 SPDT mini toggle switch (S3)
1 18-pin DIL IC socket
1 2.5mm PC-mount DC connector
1 4×2 section of DIL header strip
1 7×2 section of DIL header strip
1 jumper shunt
1 binding-post/banana socket, red
1 binding-post/banana socket, black
2 PC terminal pins, 1mm dia
4 M3 × 15mm tapped spacers
4 M3 × 6mm csk head machine screws
5 M3 × 6mm pan head machine screws
1 M3 nut (metal)
2 M2 × 6mm machine screws (for S1)
4 M3 × 12mm nylon screws
8 M3 nylon nuts
4 M3 nylon nuts with integral washers
1 9V battery-snap lead
1 10kΩ horizontal trimpot (VR1)

Semiconductors
1 PIC16F628A microcontroller, pre-programmed – see text (IC1)
1 7805 +5V regulator (REG1)
1 1N4148 signal diode (D1)
1 1N4004 1A rect. diode (D2)

Capacitors
1 22μF 16V radial elect.
2 10μF 16V radial elect.
1 10μF 16V tantalum
1 100nF monolithic
2 1nF MKT or polystyrene (1% if possible) (C1, C2)
2 33pF NPO ceramic

Resistors (0.25W 1% metal film)
3 100kΩ
1 68kΩ
1 47kΩ
2 4.7kΩ
4 1kΩ

*Available as a set from the *EPE PCB Service*

this frequency (F1) and stores it in memory. It then energises reed relay RLY1, which switches capacitor C2 in parallel with C1 and thus alters the oscillator frequency (ie, it lowers it). The microcontroller then measures and stores this new frequency (F2).

Next, the microcontroller uses these two frequencies, plus the value of C2 to accurately calculate the values of both C1 and L1. If you're interested, the equations it uses to do this are shown in the top (Calibration Mode) section of the box titled 'How it works: the equations'.

Following these calculations, the microcontroller turns relay RLY1 off again to remove capacitor C2 from the circuit, allowing the oscillator frequency to return to F1. The unit is now ready to measure the unknown inductor or capacitor (*Cx* or *Lx*).

Into the unknown

As shown in Fig.1, the unknown component is connected across the test terminals. It is then connected to the oscillator's tuned circuit via switch S1.

When measuring an unknown capacitor, S1 is switched to position 'C' so that the capacitor is connected in parallel with C1. Alternatively, for an unknown inductor, S1 is switched to position 'L' so that the inductor is connected in series with L1.

In both cases, the added values of Cx or Lx again causes the oscillator frequency to change, to a new frequency (F3). As with F2, this will always be lower than F1. So, by measuring F3 as before, and monitoring the position of S1 (which is done via the C/$\overline{\text{L}}$ connection at IC1 pin 12), the microcontroller can calculate the value of the unknown component using one of the equations shown in the lower section of the equations box – ie, the section labelled 'In measurement mode'.

From these equations, you can see that the micro has some fairly solid 'number crunching' to do, both in the calibration mode when it calculates the values of L1 and C1, and then in the measurement mode, when it calculates the value of Cx or Lx. Each of these values needs to be calculated to a high degree of resolution and accuracy. To achieve this, the micro's firmware needs to make use of some 24-bit floating point maths routines.

Circuit details

How this ingenious yet simple measurement scheme is used to produce a practical *LC* meter can be seen from the full circuit diagram of the High-Accuracy Digital LC Meter, shown in Fig.2. It's even simpler than you might have expected, because there's no separate comparator to form the heart of the measurement oscillator. Instead, we're making use of a comparator that's built into the microcontroller (IC1) itself.

As shown, microcontroller IC1 is a PIC16F628A and it actually contains two analogue comparators which can be configured in a variety of ways. Here we are using comparator 1 (CMP1) as the measurement oscillator. Comparator 2 (CMP2) is used only to provide some additional 'squaring up' of the output from CMP1, and its output then drives the internal frequency counting circuitry.

The oscillator circuitry is essentially unchanged from that shown in Fig.1. Note that IC1 controls relay RLY1 (which switches calibrating capacitor C2 in and out of circuit) via its I/O port B's RB7 line (pin 13). Diode D1 prevents the micro's internal circuitry from being damaged by inductive spikes when RLY1 switches off.

In operation, IC1 senses which position switch S1 is in using RB6 (pin 12). This is pulled high internally when S1b is in the 'C' position, and low when S1b is in the 'L' position. Crystal X1 (4MHz) sets the clock frequency for IC1, while the associated 33pF capacitors provide the correct loading to ensure reliable starting of the clock oscillator.

The results of IC1's calculations are displayed on a standard 2×16 line LCD module. This is driven directly from the micro itself, via port pins RB0 to RB5. Trimpot VR1 allows the LCD contrast to be optimised.

Firmware and link functions

The firmware in IC1 is designed to automatically perform the calibration function just after initial start-up. However, this can also be performed at any other time using switch S2.

Pressing this switch simply pulls the micro's $\overline{MCLR}$ pin (4) down, so that the micro is forced to reset and start up again, recalibrating the circuit in the process.

Links LK1 to LK4 are not installed for normal use, but are used for the initial setting up, testing and calibration. As shown, these links connect between RB3 to RB0 and ground respectively.

For example, if you fit LK1 and then press S2 to force a reset, the micro will activate RLY1 (to switch capacitor C2 into circuit) and measure oscillator frequency F2. This is then displayed on the LCD.

Similarly, if you fit LK2 and press S2, the micro simply measures the initial oscillator frequency (F1) and displays this on the LCD. This allows you to not only make sure that the oscillator is operating, but also you can check its frequency as well. We'll have more to say about this later.

Links LK3 and LK4 allow you to perform manual calibration 'tweaks' to the meter. This is useful if you have access to a capacitor whose value is very accurately known (because it has been measured using a full-scale LCR meter, for example).

With LK3 fitted, the capacitance reading decreases by a small amount each time it makes a new measurement (which is about five times per second). Conversely, if LK4 is fitted instead, the microcontroller increases the capacitance reading by a small increment each time it performs a new measurement.

Each time a change is made, the adjustment factor is stored in the micro's EEPROM, and this calibration value is then applied to future measurements. Note also that although the calibration is made using a 'standard' capacitor, it also affects the inductance measurement function.

In short, the idea is to fit the jumper to one link or the other (ie, to LK3 or LK4) until the reading is correct. The link is then removed.

As mentioned above, links LK1 to LK4 are all left out for normal operation. They're only used for troubleshooting and calibration.

Power supply

Power for the circuit is derived from an external 9V to 12V DC source. This can come from either a plugpack supply or from an internal 9V battery. The switched DC power input socket

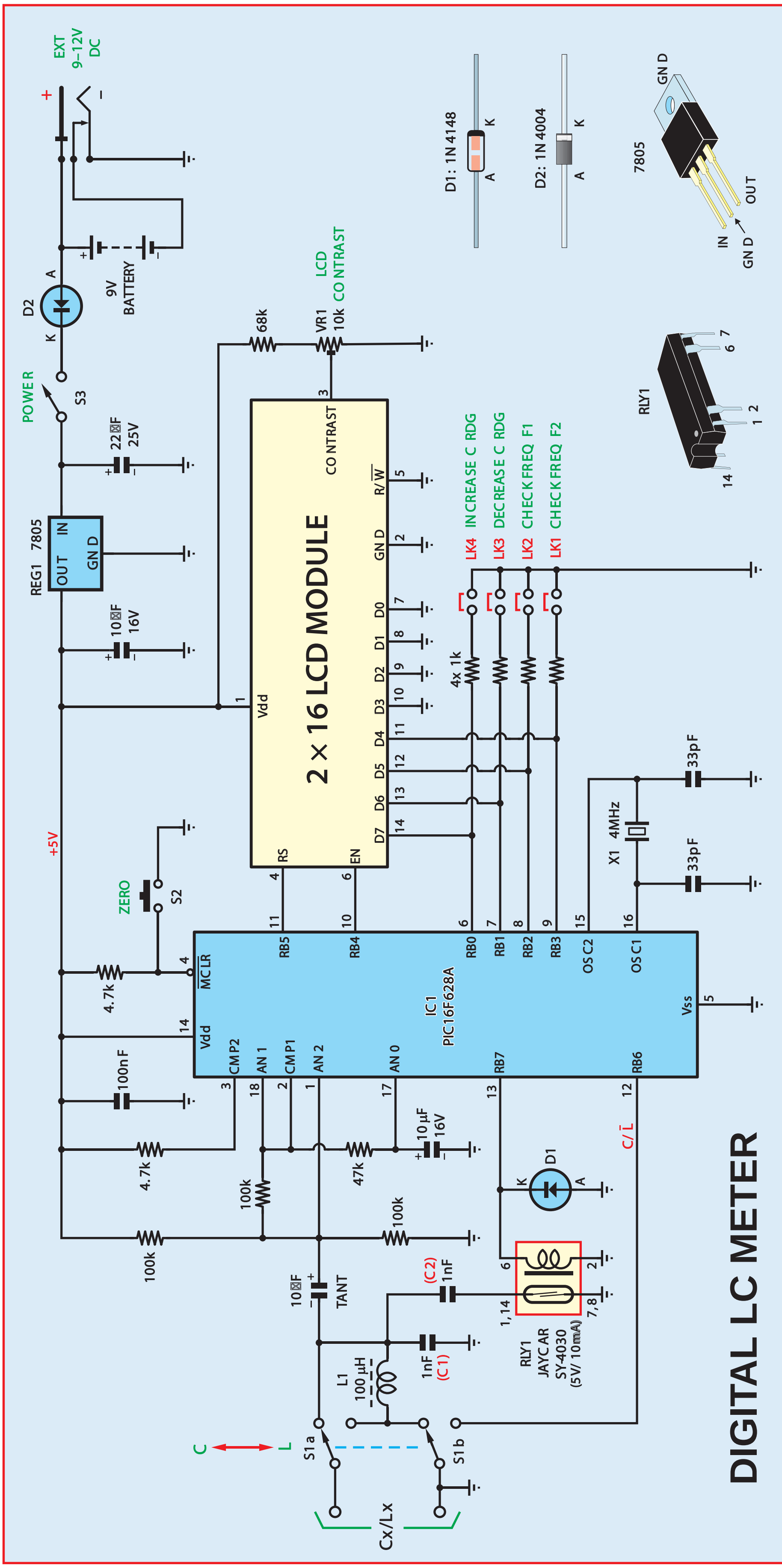


Fig.2: The complete circuit for the Digital LC Meter uses a PIC16F628A microcontroller to monitor and calibrate the oscillator and to drive the LCD module. Note that the analogue comparator shown in Fig.1 is actually built into the microcontroller.

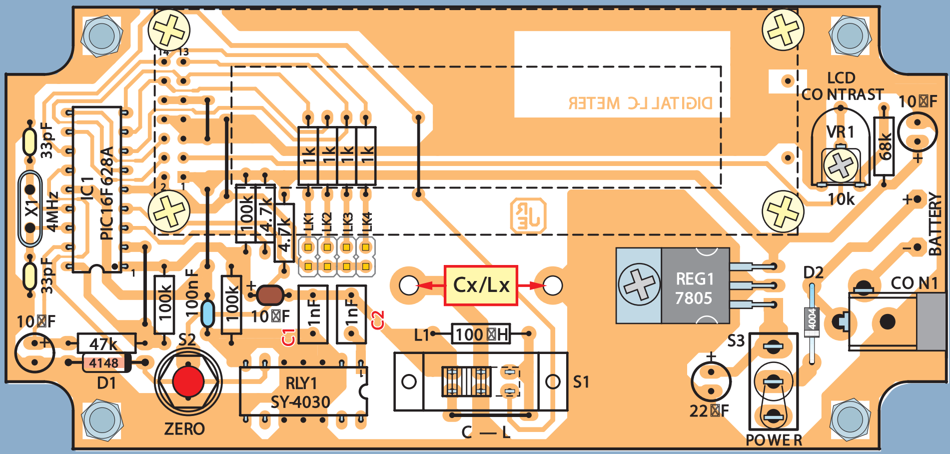
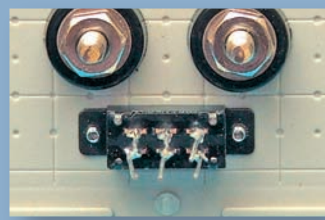
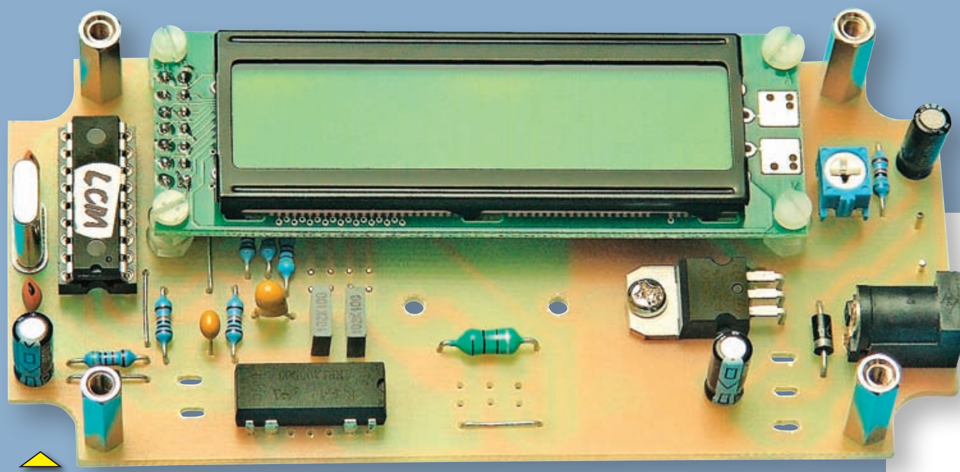


Fig.3: follow this layout diagram to build the Digital LC Meter, but don't solder in the switches or the test terminals until after these parts have been mounted on the front panel. The 2-way pin headers for links LK1-LK4 are installed on the copper side of the board – see text.



Part of the back of the case lid before the PC board assembly is attached, showing the 'extension leads' soldered to slide switch S1's terminals.



The PC board assembly is attached to the case lid using M3 × 15mm spacers and M3 × 6mm countersink (csk) machine screws. Make sure that the assembly is secure before soldering the switch lugs and test terminals.

automatically disconnects the battery when the plugpack supply is connected.

The incoming DC rail is fed via reverse polarity protection diode D2 and power switch S3 to regulator REG1 – a standard 7805 device. The resulting +5V rail at REG1's output is then used to power IC1 and the LCD module.

Software

The software files are available via the *EPE* Library site, accessed via **www.epemag.com**. Pre-programmed PICs are available from Magenta Electronics – see their advert in this issue for contact details.

Construction

Because it uses so few parts, the unit is very easy to build. All the parts, except for switches S1 to S3 and the Cx/Lx input terminals, are mounted on a PC board, code 745, measuring 125 × 58mm. This board is available from the *EPE PCB Service.*

The LCD module connects to a 7×2 DIL pin header at one end of the board, and is supported at either end using M3 nylon screws and nuts.

Fig.3 shows the parts layout on the PC board. Here's the suggested order of fitting the components to the PC board:

1) Fit DC power connector CON1 and the two 1mm PC board terminal pins for the internal battery connections.
2) Fit the six wire links, four of which go under where the LCD module is later fitted. Don't forget the link immediately below switch S1.
3) Install the 4×2 DIL pin header used for links LK1 to LK4. **Note that this item must be mounted on the copper side of the board (not on the top),** so that a jumper can later be fitted to any of the links when the board assembly is attached to the box lid).

To install this header, just push the ends of the longer sides of the pins into the board holes by 1-2mm, then solder them carefully to the pads. That done, push the plastic strip down the pins so that it rests against the solder joints,

Table 1: Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	3	100kΩ	brown black yellow brown	brown black black orange brown
❏	1	68kΩ	blue grey orange brown	blue grey black red brown
❏	1	47kΩ	yellow violet orange brown	yellow violet black red brown
❏	2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❏	4	1kΩ	brown black red brown	brown black black brown brown

leaving the clean outer ends of all pins free to take a jumper shunt.

4) Fit a 7×2 DIL pin header for the LCD module connections. This header is fitted to the top of the PC board in the usual way.
5) Install the 11 resistors, seven of which go under the LCD module. Table 1 shows the resistor colour codes, but you should also check each resistor using a DMM before soldering in position on the board.
6) Install trimpot VR1, followed by inductor L1 and reed relay RLY1.
7) Fit the five non-polarised capacitors, followed by the 10μF tantalum, the two 10μF radial electrolytics and the 22μF radial electrolytic. Note that the tantalum capacitor and the electrolytics are polarised, so take care with their orientation.
8) Install DIL relay RLY1, the 18-pin socket for IC1 and the 4MHz crystal X1. Follow these parts with diodes D1 and D2 and regulator REG1.

   Note that the regulator's leads are bent downwards through 90° 6mm from the body, so that they pass through the holes in the board. Before soldering the leads, secure the metal tab to the PC board using an M3 × 6mm machine screw and nut.
9) Secure the LCD module to the PC board, using four M3 × 12mm cheesehead nylon screws and 12 nuts (three on each screw). Fig.4 shows the details.

   At each mounting point, two plain nuts act as spacers between the module and the PC board, while a third nut with an integral washer is fitted to secure the assembly under the PC board. Note that when you're fitting the module to the top of the board, it should be lowered carefully so that the holes at the lefthand end slip down over the pins of the 7×2 DIL strip fitted earlier.
10) Solder the 14 pin connections on the top of the LCD module using a fine-pointed iron.
11) Plug the programmed PIC16F628A (IC1) into its socket, then fit four M3 × 15mm tapped spacers to the PC board mounting points. Secure these spacers using M3 × 6mm panhead screws.

That completes the board assembly. It can now be placed to one side while you work on the case.

Preparing the case

As shown in the photographs, the PC board assembly is mounted on the lid of a standard UB3-size box.

If you're building the Digital LC Meter from a kit, the plastic case will probably be supplied with all holes drilled and with screen-printed lettering for the front panel. If so, it will be simply a matter of fitting the switches and binding 'test' posts to the lid.

Note that slide switch S1 is secured using two M2 × 6mm machine screws, while switches S2 and S3 are mounted using their own mounting nuts and lockwashers. The binding posts mount to the panel in the same way.

If you have to drill the case holes yourself, you can use a photocopy of the front panel artwork (Fig.5) as a drilling template. In addition, you will have to drill/ream a 10mm diameter hole in the righthand end of the box to give access to the DC connector (CON1). This hole should be positioned 22mm from the front edge of the case and 9mm down from the lid, so that it aligns correctly with CON1.

That done, a copy of the front panel artwork can be attached to the lid using an even smear of neutral-cure silicone sealant and the holes cut out using a sharp hobby knife.

Once all the panel hardware is in place, the next step is to fit the PC board. The first thing to note here is that the rear lugs of switches S2 and S3 will pass through their PC pads when the board is mounted on the lid, with just enough metal protruding to allow soldering.

This also applies to the binding post terminals. **However, slide switch S1's lugs are not long enough for this, so after the switch is mounted on the lid, a short length of tinned copper wire (eg, a resistor lead offcut) must be soldered to each lug to extend its length.**

By the way, when you're fitting these short extension wires, it's a good idea to make a small hook at the end of each wire and pass it through the lug's hole before squeezing it with needle-nose pliers. The idea here is to ensure that, once soldered, it's not going to fall out when the lower ends of the wires are later soldered to the board pads.

Once the extension wires have been fitted, you should be able to fit the PC board assembly on the lid so that all the switch and binding post leads pass through their matching board holes. That done, you can fasten it all together using four M3 x 6mm countersink head screws, which pass through the front of the lid and into the spacers.

The assembly can now be completed by soldering the switch and binding post leads and by fitting the battery snap connector.

Checkout and calibration

Your LC meter is now ready for testing and calibration. To do this, first connect a plugpack supply or a 9V alkaline battery to the unit, set slider switch S1 to the 'Capacitance' position and switch on using S3. As soon as power is applied, the message 'Calibrating' should appear on the LCD for a second or two, then the display should change to read 'C = NN.N pF', where NN.N is less than 10pF.

If this happens, then your meter is probably working correctly, so just leave it for a minute or two to let the test oscillator stabilise. During this time the capacitance reading may vary slightly by a few tenths of a picofarad as everything settles down – that's normal.

Now press 'Zero' button S2 for a second or two and release it. This forces the microcontroller to start up again and recalibrate, so you'll briefly see the 'Calibrating' message again and then 'C = 0.0pF'. This indicates that the microcontroller has balanced out the stray capacitance and reset its zero reference.

Troubleshooting

If you don't get any messages displayed on the LCD, chances are that you've connected either the battery snap lead or the plugpack lead's connector with reversed polarity. Check the supply connections carefully. With power applied, you should be able to measure +5V on pin 14 of IC1 with respect to ground (0V).

Alternatively, if you get some messages on the LCD, but they're not as described, it's time to check that the meter's test oscillator is working properly. To do this, switch off, fit jumper shunt LK2 (ie, at the back of the board), then apply power and watch the LCD.

After the 'Calibrating' message, the micro should display an eight-digit number which represents the oscillator frequency F1. This should be between about 00042000 and 00058000, if your components for L1 and C1 are within the usual tolerance.

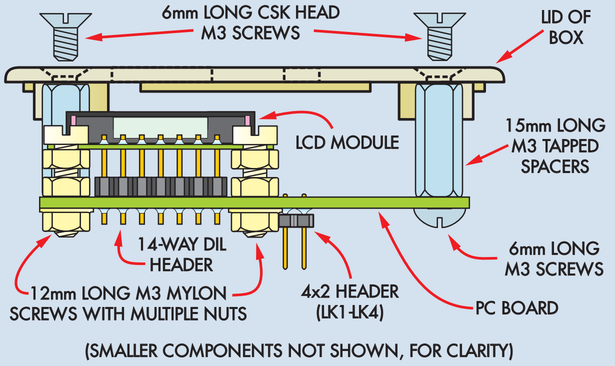
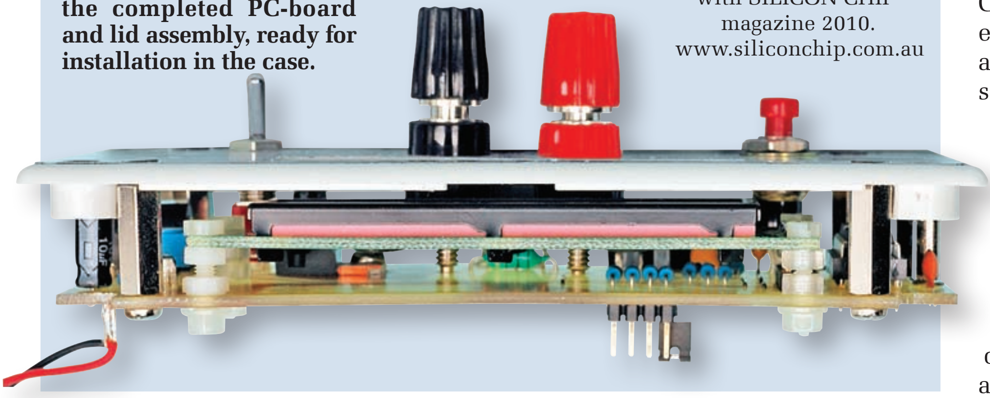


Fig.4: here's how the assembly goes together. The LCD module is mounted using Nylon screws and nuts, while the completed board assembly is attached to the case lid using M3×15mm tapped spacers and machine screws.

Below: this side view shows the completed PC-board and lid assembly, ready for installation in the case.



If the figure you get for F1 is '00000000', your test oscillator isn't working and you will need to switch off and look for the cause. The possibilities include missed solder joints, a poor solder joint involving one of the oscillator components, or perhaps a tiny sliver of solder bridging adjacent copper tracks or pads.

If you do get a figure in the correct range, write the value down, then switch off and transfer the jumper shunt to the LK1 position. Re-apply power and check that the LCD now shows a different eight-digit number after calibrating. This will be F2 – ie, the oscillator frequency when capacitor C2 is switched in parallel with C1.

Because the two capacitors are nominally the same value, F2 should be very close to 71% of F1. That's because doubling the capacitance reduces the frequency by a factor equal to the square root of two (ie, $1/\sqrt{2} = 0.707$). If your reading for F2 is well away from 71% of F1, you may need to replace C2 with another capacitor whose value is closer to C1.

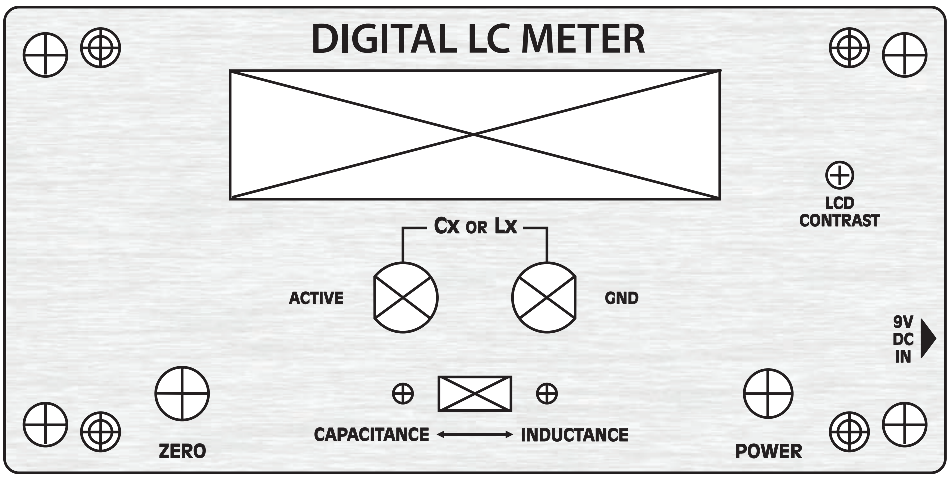


Fig.5: this full-size front-panel artwork can be used as a drilling template for the front panel.

On the other hand, if F2 is exactly the same as F1, this suggests that relay RLY1 is not actually switching C2 in at all. This could be due to a poor solder joint on one of RLY1's pins or you may have wired it into the board the wrong way around.

Once you do get sensible readings for F1 and F2, your Digital LC Meter will be ready for calibration and/or use. If you don't have a capacitor of a known value to perform your own accurate calibration, you'll have to rely on the meter's own self-calibration (which relies largely on the accuracy of capacitor C2). In this case, just remove any jumpers from LK1 to LK4 and fit your meter assembly into its box, using self-tapping screws to hold everything together.

The battery sits in the bottom of the case. It is secured by wrapping it in foam, so that it is firmly wedged in place when the lid assembly is fitted to the case.

Fine-tuning the calibration

If you happen to have a capacitor of known value (because you've been able to measure it with a high-accuracy LCR meter), you can easily use it to fine-tune the Digital LC Meter's calibration.

First, switch the unit on and let it go through its 'Calibrating' and 'C = NN.N pF' sequence. That done, wait a minute or two and press the Zero button (S2), ensuring that the LCD then shows the correctly zeroed message – ie, 'C = 0.0 pF'.

Next, connect your known-value capacitor to the test terminals and note the reading. It should be fairly close to the capacitor's value, but may be somewhat high or low.

If the reading is too low, install link LK4 on the back of the board and watch the LCD display. Every 200ms or so, the reading will increment as the PIC microcontroller adjusts the meter's scaling factor in response to the jumper. As soon as the reading reaches the correct figure, quickly remove the jumper to end the calibration adjustment.

Conversely, if the meter's reading for the known capacitor is too high, follow the same procedure, but with the jumper in the LK3 position. This will cause the micro to decrement the meter's scaling factor each time it makes a measurement, and as before, the idea is to remove LK3 as soon as the reading reaches the correct figure.

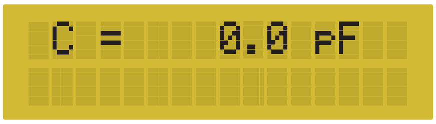


Fig.6: this is what appears on the LCD screen after zeroing the unit in Capacitance mode.

If you are not fast enough in removing the jumper during either of these calibration procedures, the microcontroller will 'overshoot'. In that case, you simply need to use the opposite procedure to bring the reading back to the correct figure. In fact, you may need to adjust the calibration back and forth a few times until you're satisfied that it is correct.

As previously mentioned, the PIC microcontroller saves its scaling factor in its EEPROM after every measurement during these calibration procedures. That means that you only have to do the calibration once. Note also when you calibrate the meter in this way using a known-value capacitor, it's also automatically calibrated for inductance measurements.

Using it

The Digital LC Meter is easy to use. Initially, you just switch it on, set S1 to Capacitance (NOT Inductance), wait a minute or two for it to stabilise and then zero it using pushbutton S2. It's then just a matter of connecting the unknown component to the test terminals, selecting 'Capacitance' or 'Inductance' using S1 and reading the component's value off the LCD.

Alternatively, you can zero the Digital LC Meter on the 'Inductance' range by fitting the shorting bar shown in Fig.7 (since this bar has virtually zero inductance). This shorting bar is initially connected between the test terminals, and switch S2 is then pressed to zero the reading. That done, the shorting bar is removed and the unknown inductor connected across the test terminals.

Note, if you don't have S1 (Capacitance/Inductance) in the correct position, the micro will usually give an 'Over Range' error message on the LCD. This will also occur if the component's value is outside the meter's measuring range – ie, above about 800nF for capacitors or 70mH for inductors. *EPE*

Adaptor board for very small capacitors

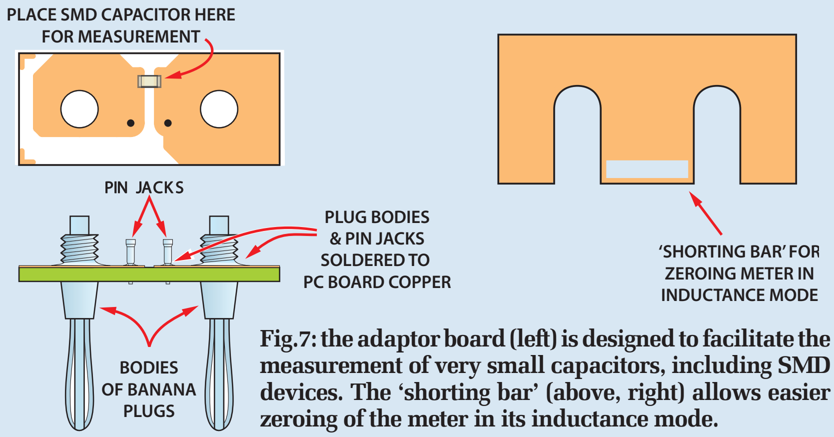


Fig.7: the adaptor board (left) is designed to facilitate the measurement of very small capacitors, including SMD devices. The 'shorting bar' (above, right) allows easier zeroing of the meter in its inductance mode.

To help measure very small capacitors – including trimmers and SMD capacitors – we have designed a small adaptor board which can be plugged into the meter's binding post terminals. This adaptor board provides a pair of closely spaced pin jacks, along with copper pads separated by a 1mm gap.

The pin jacks make it easier to measure small leaded capacitors and very small trimmers, while the copper pads alongside are for measuring SMD capacitors.

The adaptor board is easily assembled. It mounts copper-side-up on two banana plugs, which are soldered to the copper around the two large holes. That done, the two pin jacks (cut from a SIL or DIL socket strip) are soldered into the two smaller holes.

To use this adaptor board, you simply plug it into the top of the Digital LC Meter's binding posts and then press the Zero button (S2) to force the meter to cancel out the additional stray capacitance. You can then measure small leaded capacitors, trimmers or SMD capacitors simply by applying them to the top of the adaptor.

Finally, we have also designed a second small adaptor board which acts as a 'shorting bar'. It connects between the two normal binding posts of the Digital LC Meter, to allow zeroing of the meter in its **inductance** mode.

Using A Backlit LCD

Either the Jaycar QP-5515 LCD module (no backlight) or the QP-5516 LCD module (with backlight) or similar can be used with this project.

If you intend running the unit from a plugpack or if battery use will only be for short periods, then the backlit version can be used. Alternatively, for general battery use, we recommend the non-backlit version – its current consumption is much lower and so the battery will last a lot longer.

Acknowledgements

The Digital LC Meter described in this article is based on a 1998 design by Neil Hecht of 'Almost All Digital Electronics', in Auburn, Washington, US (see his website at **www.aade.com**).

Mr Hecht's design used a PIC16C622 microcontroller, together with an LM311 comparator in the measuring oscillator. His firmware also made use of floating-point maths routines for PIC processors. These were written by Frank Testa, and made available on the website of PIC manufacturer Microchip Technology (**www.microchip.com**).

Since then, various people have produced modified versions of the design, including Australian radio amateur Phil Rice, VK3BHR of Bendigo, Victoria. Mr Rice and others have also modified the firmware and adapted it to use the PIC16F628 micro with its internal comparator. They also added the firmware calibration facility. Further information on Mr Rice's version can be found on the website of the Midland Amateur Radio Club (**www.marc.org.au**).

In summary, a great deal of the credit for this latest version of the design must go to those earlier designers. The author acknowledges their work.

Hybrid Heaters And Nanostuff

TechnoTalk

Mark Nelson

Few would deny that energy conservation and carbon reduction are key issues of the moment, even if most politicians display far too little commitment to, or understanding of, the issues. Our leaders may be doing too little, but we really can do something, even if our motivation is more on saving money than the planet – 'every little helps'. Electronics research is playing a vital part too, as Mark Nelson now explains.

Just before Christmas, the politicians demonstrated their true level of commitment to combating climate change. The only people who took comfort from this weak-willed capitulation were those who deny the existence of climate change. But however disappointed, depressed (or bored stiff) you may be by the argument and counter-argument, your wallet must be interested in the energy conservation measures that will save you money as well as save the planet.

Hybrid heater has star quality

The word hybrid has always caused me problems. The concept implies neither fish nor fowl, and smacks of the same kind of compromise as a seminar (why not go the whole hog and settle for an entire 'nar'?). Nevertheless, General Electric (US) has struck a blow against energy wastage with its new-technology water heater, hybrid or not. This all-new design provides the same amount of domestic hot water as traditional heaters do, but saves users up to $320 (£200) a year on their electricity bills. That's a 62% reduction on monthly utility bills for years to come. Little wonder that this appliance has achieved Energy Star rating.

So how does it work? The tank portion of this electric water heater includes two electric heating elements, a pressure relief valve, an internal porcelain-lined tank and an anode rod. But what truly sets this product apart sits just above the tank. In a nutshell, this is a heat pump that draws warmth out of the surrounding air and transfers it into the tank.

A compressor and evaporator are integrated into the electric water heater unit and the evaporator draws in ambient heat from surrounding air using two variable speed fans. Condenser coils wrap the tank all the way to the bottom to transfer this heat into the tank and heat the water.

There's a 3-D animation at **www.geappliances.com/heat-pump-hot-water-heater/electric-water-heater-features.htm**, where you can also read about the easy-to-use control panel and back-lit LCD display that enable users to select the five different operational modes that optimise the way the heater works.

Right now, demand for these heaters is outrunning production, which is not surprising as the price at around £1,000 is no more than an equivalent 'old-technology' hybrid heater. With a payback like this I certainly want one of these, but like you, I shall have to watch out for similar products to appear over here in the not too distant future.

Scavengers update

A few months back we covered energy scavenging from the trample of punters' feet, the weight of cars driving over treadle plates in supermarket car parks and even microchips harvesting radio frequency energy. But there are other techniques, and there are now sensor modules on the market that harvest tiny but useful amounts of energy from their surroundings using light, temperature change and rotation, as well as vibration, linear motion and pressure. The energy is fully adequate to register detected values and transmit data wirelessly.

At the forefront in free energy acquisition is the company EnOcean (**www.enocean.com/en/energy-harvesting**), which offers solutions for powering electronic circuitry by a choice of either solar, thermal or mechanical means. Their white paper, *Energy For Free*, is a fascinating read, and you can download it for free from their website, along with application notes, data sheets and much more.

Blue skies research

My eyes lit up recently when I saw a headline referring to microwave fridges and nano diving boards. It appeared to make sense, as you can have gas refrigerators as well as gas ovens. So, logically alongside microwave ovens why not microwave fridges as well, especially as these are an international first developed by our very own National Physical Laboratory?

'Now read on', as they say in the best serialised stories. And as I read on, I discovered that the application of these fridges is not in households, but in quantum physics labs. Disappointing, but at least they do save a lot of energy. In fact, NPL scientists are paving the way for highly accurate measurement of nano-scale matter, by being the first team in the world to develop a tiny microwave-powered room-temperature fridge.

This microwave refrigerator cools tiny devices, called micro or nano-scale mechanical resonators, to –170°C. Cooling these devices, which look and behave like tiny diving boards, down to that level is vital to making accurate measurements.

Any material that is warmer than absolute zero (–273°C) will have atoms moving around inside it, and this makes it very difficult to measure certain parameters accurately. NPL has developed a technique that selectively cools down just the property of a sample that needs to be measured, saving an enormous amount of energy.

This technique will be of great use in nano-scale and quantum physics, as it allows scientists to detect tiny changes in physical factors such as mass, force and displacement by accurately measuring changes in the resonant frequency of the 'diving board'. This means it can be used in applications where highly sensitive detection is needed, such as bio-analytical screening for viruses (by catching a virus on the diving board). In the longer term this technique could lead to development of even more sensitive 'quantum' diving boards that could be used to examine the really big questions of quantum physics, such as at what scale quantum effects break down?

Nonsense

Maybe you find this research into microwave fridges just far-fetched nonsense, exactly as you might have thought back in 1946 reading new a book by Miles Henslow called *The Miracle of Wireless*.

> *Radio welding' used during the war, … which is really a method of creating and localising a rapid, intense heat is in use today in the manufacture of plywood and plastics. Glues can be hardened and set within seconds instead of hours. Sausage and chops can be cooked in half a minute by the pressing of a switch.*

Cooking food by wireless – how utterly ridiculous! Yet I bet there's a microwave oven in your kitchen, so perhaps future science has a value after all. Check out this too: another ludicrous prediction by Henslow, in the same book.

> *Maybe it will sound a far-fetched idea today, but the time is surely approaching when everyone will be able to carry about with him a small radio telephone. Wartime development of apparatus to work on very short wavelengths has opened up many entrancing possibilities.*
>
> *Hundred of thousands of 'radio-telephone channels' can be used over short distances without interference; and the installation of a network of automatic telephone exchanges might well be utilized for handling the calls from a multitude of pedestrian or automobile telephone subscribers, to sort them out and pass them by line – or by radio link – to main exchanges. Certainly it is but a matter of time before the railway traveller is able to pick up the phone and dial his office or his home.*

That matter of time was 40 years, but you should never underestimate the potential of blue skies research and invention!

2-Way Stereo Headphone Adaptor

By Mauro Grassi

Do you have a stereo amplifier without a headphone socket, but want to listen to your music via headphones? If so, this versatile Stereo Headphone Adaptor will do the job. It connects between your amplifier and loudspeakers, has several operating modes and features two output sockets with individual volume controls.

IF YOU built our 20W Class-A Stereo Amplifier Module described in the Oct '08 issue, you will be aware that it lacks a headphone socket. Similarly, many hifi valve amplifiers also lack a headphone socket, the assumption being that a true hifi enthusiast will want to listen via good-quality loudspeakers.

A headphone output was not included in the Class-A Stereo Amplifier because it would degrade its superb audio performance. Both the wiring paths and the general circuit layout are critical factors in the design, and any changes, however slight, can cause big changes in the signal-to-noise ratio and harmonic distortion figures of the amplifier.

Headphone listening

If you do want to listen via headphones, a far better option is to build the simple Stereo Headphone Adaptor presented here. It connects directly to the amplifier's speaker terminals and switches the loudspeakers and stereo headphone sockets using two DPDT (double-pole, double-throw) relays, so there's no chance of it degrading the audio performance.

As mentioned in the introduction, you can connect up to two sets of stereo headphones. These can be switched on or off at the touch of a button, and the volume of each can be individually controlled. In addition, the loudspeakers can be switched on or off and there's also a mute switch, which turns everything off.

This means that you can operate the system in one of four modes:

- Loudspeakers only
- Headphones only
- Headphones and loudspeakers operating together
- Mute (all off). It's also possible to mute the system by individually turning the headphones and the speakers off.

Perhaps we should clarify the operation of the mute switch, as it doesn't function quite like a traditional mute switch. Pressing it once certainly mutes the headphones and/or loudspeakers, but pressing it a second time doesn't 'unmute' the system. Instead, you have to press either the 'phones' button or the 'headphone' button (or both) to restore the sound.

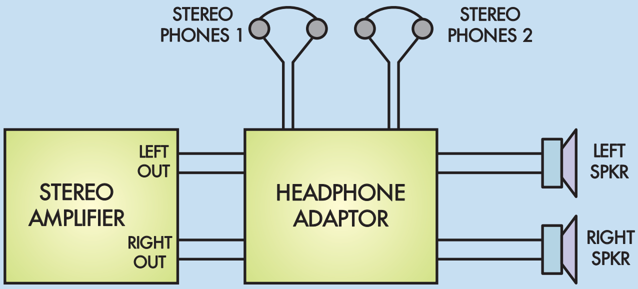


Fig.1: the Stereo Headphone Adaptor connects between your stereo amplifier and the loudspeakers. It can drive two pairs of headphones.

DPDT relays

Because it uses two DPDT relays to do the switching, the Stereo Headphone Adaptor can be used with amplifiers with quite high power outputs. In fact, it's good for use with amplifiers with outputs up to about 100W RMS or more, *provided you're sensible with the Volume control setting on the amplifier*.

We've also designed the unit to not only work with solid-state amplifiers, but also with valve amplifiers as well. The latter must be taken into account separately because unlike solid-state amplifiers, operating a valve amplifier without a load (ie, a loudspeaker) can cause problems.

The reason why most valve amplifiers should not be operated without a load is that they can sometimes oscillate supersonically. Worse still, they can then produce very high AC voltages in the primary windings of the output transformers. These voltages can be so high that they can cause flashover across the valves sockets or even within the valves themselves. This will not only damage the valves, but other components as well.

As shown in the photos, the unit is housed in a low-profile instrument case with the volume controls, headphone sockets and pushbutton switches neatly laid out on the front panel. The miniature pushbutton switches incorporate integral LEDs, which indicate the settings – red for 'power on', green for 'phones on' and blue for 'speakers on'.

On the rear panel (see below) is a DC power socket and nine gold-plated binding-post terminals. Eight of these terminals are used to connect the amplifier input and loudspeaker output leads, while the ninth terminal connects to the amplifier's chassis and is the earth return for the headphone sockets.

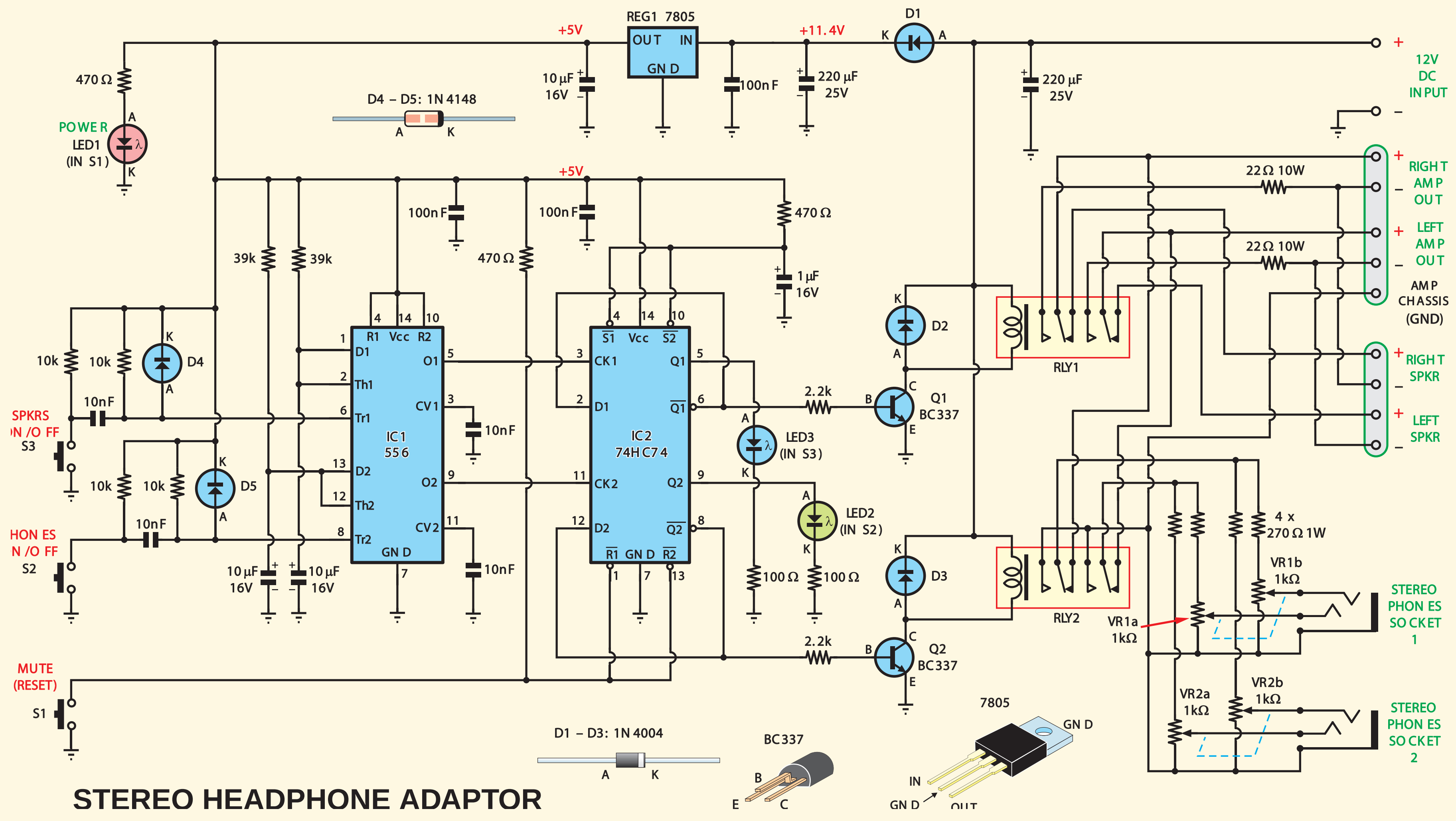
Default setting

The default mode setting was an important consideration in designing this circuit. We opted to have both the loudspeakers and the headphones on when the circuit is unpowered, and this is done using the normally-closed (NC) contacts of the relays. The advantage of this scheme is that the loudspeakers (and the headphone outlets for that matter) will operate normally when the unit is switched off (ie, zero power consumption).

This is also the default setting when power is first applied to the unit. After that, it's just a matter of using the pushbutton switches to toggle the loudspeakers and the headphones off and on.

The leftmost switch is the mute switch and, as mentioned, this turns both the loudspeakers and the headphones off (but not on again). This switch carries a red LED, which is permanently lit while power is applied – ie, this LED simply serves as a power on indicator.

The rear panel carries gold-plated binding-post terminals for the loudspeaker and amplifier connections, plus a DC power socket. Power comes from a 12V DC 400mA plugpack.



STEREO HEADPHONE ADAPTOR

Fig.2: the circuit uses two DPDT (double-pole, double-throw) relays to toggle the loudspeakers and/or stereo headphone outputs when switches S2 and S3 are pressed. IC1, a 556 dual timer, debounces these two switches and its outputs at pins 5 and 9 each clock one section of dual D-type flip-flop IC2 whenever a switch is pressed. IC2's $\overline{Q}$ outputs (pin 6 and 8) in turn drive transistors Q1 and Q2, which then control the relays.

The next switch controls the two headphone sockets, and its green LED lights when the headphones are on. Finally, the third switch controls the speakers and its blue LED lights when the speakers are on. These latter two switches toggle their respective outputs on or off each time they are pressed.

Note that when the loudspeaker switch is toggled to the off position, it places dummy 22Ω loads across the amplifier's left and right channel outputs – ie, these loads appear in place of the speakers. This is done to accommodate valve amplifiers, as these should be loaded at all times as explained earlier.

Circuit details

Refer now to Fig.2 for the full circuit details. It's based on two ICs (IC1 and IC2), a couple of transistors (Q1 and Q2) and the aforementioned DPDT relays (RLY1 and RLY2).

IC2, a 74HC74 dual D-type flip-flop, forms the heart of the circuit. This is wired in toggle mode, with its D1 and D2 inputs directly connected to their corresponding $\overline{Q1}$ and $\overline{Q2}$ outputs. The two set inputs ($\overline{S1}$ and $\overline{S2}$) are connected to a power-on reset circuit consisting of a 470Ω resistor and a 1µF capacitor, while the two resets ($\overline{R1}$ and $\overline{R2}$) are connected to ground via the mute (reset) switch S1.

In operation, the D-type flip-flop toggles its outputs on the rising edges of the clock signal pulses. When that happens, the state of the D input (either a logic high or low) is transferred to the Q output and $\overline{Q}$ toggles to the opposite state.

For example, let's assume that IC2's Q1 output (pin 5) is low. This means that $\overline{Q1}$ (pin 6) and D1 (pin 2) will both be high. When the next clock pulse arrives, the high on D1 is transferred to Q1 and $\overline{Q1}$ and D1 toggle low.

Similarly, on the next clock pulse, the low on D1 is transferred to the Q1 output, and $\overline{Q1}$ and D1 then toggle high again.

When power is first applied, the two set inputs (pins 4 and 10) are pulled low via the 1µF capacitor. This sets IC2's Q outputs high and so $\overline{Q1}$ and $\overline{Q2}$ are both low, and transistors Q1 and Q2 are off.

As a result, the relays also remain off and the loudspeakers and headphone outputs are switched on via the NC (normally closed) contacts. In addition,

Parts List – 2-Way Stereo Headphone Adaptor

- 1 PC board, code 748, available from the *EPE PCB Service*, size 172 × 104mm
- 1 ABS instrument case, size 190 × 140 × 50mm
- 1 12V 400mA DC plugpack
- 2 control knobs
- 2 12V DPDT relays with 10A 230V AC contacts (Jaycar SY-4065) (RLY1, RLY2)
- 2 6.35mm PC-mount stereo jack sockets
- 3 3-way heavy-duty PC-mount screw terminal blocks
- 1 PC-mount 2.5mm DC socket, or
- 1 panel-mount 2.5mm DC socket
- 4 self-adhesive rubber feet
- 2 M3 × 12mm machine screws
- 1 M3 × 6mm machine screw
- 3 M3 nuts
- 2 M3 × 6mm tapped spacers
- 4 panel-mount gold-plated binding posts, red
- 5 panel-mount gold-plated binding posts, black
- 1 1m-length of heavy-duty speaker cable
- 1 300mm-length tinned copper wire for links

Semiconductors
- 1 NE556 dual timer IC (IC1)
- 1 74HC74 dual D-type flip-flop (IC2)
- 2 BC337 *NPN* transistors (Q1, Q2)
- 1 7805 +5V regulator (REG1)
- 3 1N4004 rect. diodes (D1 to D3)
- 2 1N4148 signal diodes (D4, D5)

Switches
- 1 SPST horizontal PC-mount tactile switch, with green LED (Jaycar SP-0616)
- 1 SPST horizontal PC-mount tactile switch, with red LED (Jaycar SP-0615)
- 1 SPST horizontal PC-mount tactile switch, with blue LED (Jaycar SP-0617)

Capacitors
- 2 220µF 25V radial electrolytic
- 3 10µF 16V radial electrolytic
- 1 1µF 16V radial electrolytic
- 3 100nF monolithic
- 4 10nF ceramic

Resistors (0.25W 1% metal film)

2 39kΩ	3 470Ω
4 10kΩ	4 270Ω 1W
2 2.2kΩ	2 100Ω

- 2 22Ω (10W wirewound)
- 2 1kΩ dual 16mm log pots (VR1, VR2)

LED2 and LED3 both light (since the two Q outputs are high) to indicate that the speakers and the headphones are on.

Dual timer

IC1 is a 556 dual timer and is basically two independent 555 timers in one package. Both sections are configured as one-shot monostables with pulse widths of just under 0.5s. They are used to debounce switches S2 (phones on/off) and S3 (speakers on/off), to provide clean clock pulses for the D inputs of IC2.

This debouncing circuitry is necessary because the metal contacts in the switches tend to 'bounce' as they close. As a result, we get a series of short pulses from the switches instead of just one pulse. If these pulses were fed directly to the clock (CK) inputs of IC2, there's no guarantee that the flip-flops would toggle, as the switches are just as likely to produce an even number of pulses as an odd number.

The monostables in IC1 eliminate this problem. As shown, switches S2 and S3 are connected to the trigger inputs (Tr1 and Tr2) of the monostables via 10nF capacitors. When a switch is pressed, its corresponding trigger input is briefly pulled low (via one of the 10nF capacitors) and this triggers the monostable.

As a result, the monostable's output (pin 5 or pin 9) goes high and applies a positive-going clock pulse to the relevant clock input of IC2. This causes the corresponding D-type flip-flop to toggle.

For example, let's assume that the circuit is powered up and is in the default state. If switch S3 is now pressed, pin 5 of IC1 goes high for about 0.5s and applies a clock pulse to pin 3 (CK1) of IC2. As a result, the relevant flip-flop toggles and sends its $\overline{Q1}$ output high.

This turns on transistor Q1 and relay RLY1, and so the NC (normally

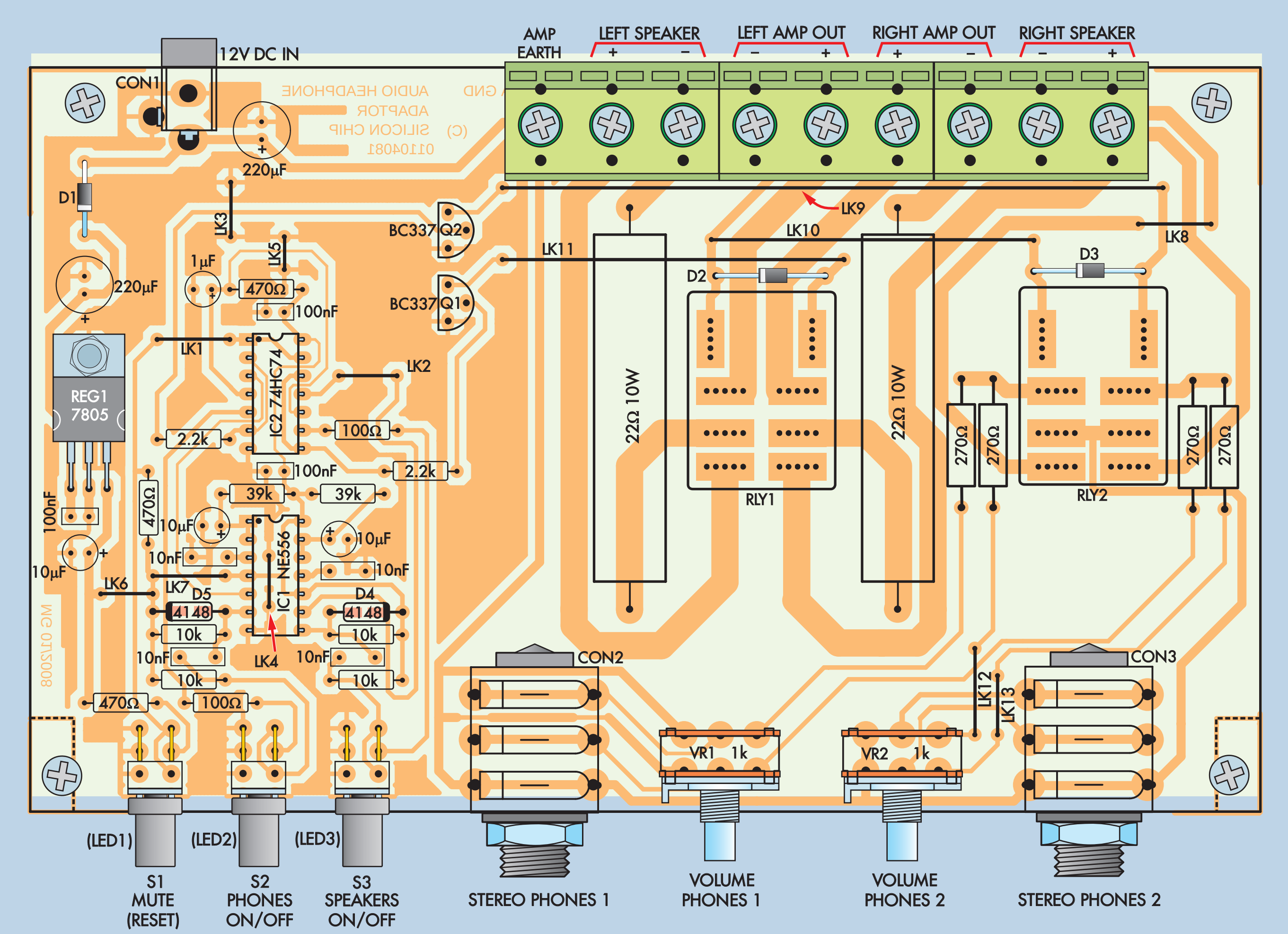


Fig.3: install the parts on the PC board as shown here. Leave the DC socket out if you intend mounting the board in a case and note that the two 22Ω 10W resistors must be mounted 3-4mm proud of the board to allow air to circulate beneath them for cooling. It is recommended that the two ICs be mounted in IC sockets.

closed) contacts open and disconnect the loudspeakers. At the same time, the relay's NO (normally open) contacts switch two 22Ω 10W resistors across the amplifier outputs to provide the dummy loads. In addition, LED 3 turns off since IC2's Q1 output is now low.

Pressing switch S3 again retriggers the monostable and toggles the flip-flop to its opposite state, so that $\overline{Q1}$ is low again. This turns off transistor Q1 and RLY1 and reconnects the loudspeakers via the relay's NC contacts. In addition, LED3 turns on (to indicate that the speakers are on) since IC2's Q1 output is now high.

Switch S2 and its following circuitry work in exactly the same fashion to control transistor Q2 and relay RLY2. This relay, in turn, switches the signals from the left and right channel amplifier outputs to the two headphone sockets (via the volume controls).

Both the ring (right channel) and tip (left channel) terminals of the headphone sockets are driven via 270Ω 1W resistors and dual 1kΩ log potentiometers VR1 and VR2, the latter functioning as Volume controls. Even with the volume wound right up, the 270Ω resistors should provide sufficient attenuation to protect the headphones from damage.

Note, however, that you should increase these resistors to 680Ω or more if you have high-impedance (say 600Ω) headphones.

The sleeve (ie, earth) terminal of each headphone socket is connected to the amplifier chassis to provide the ground return.

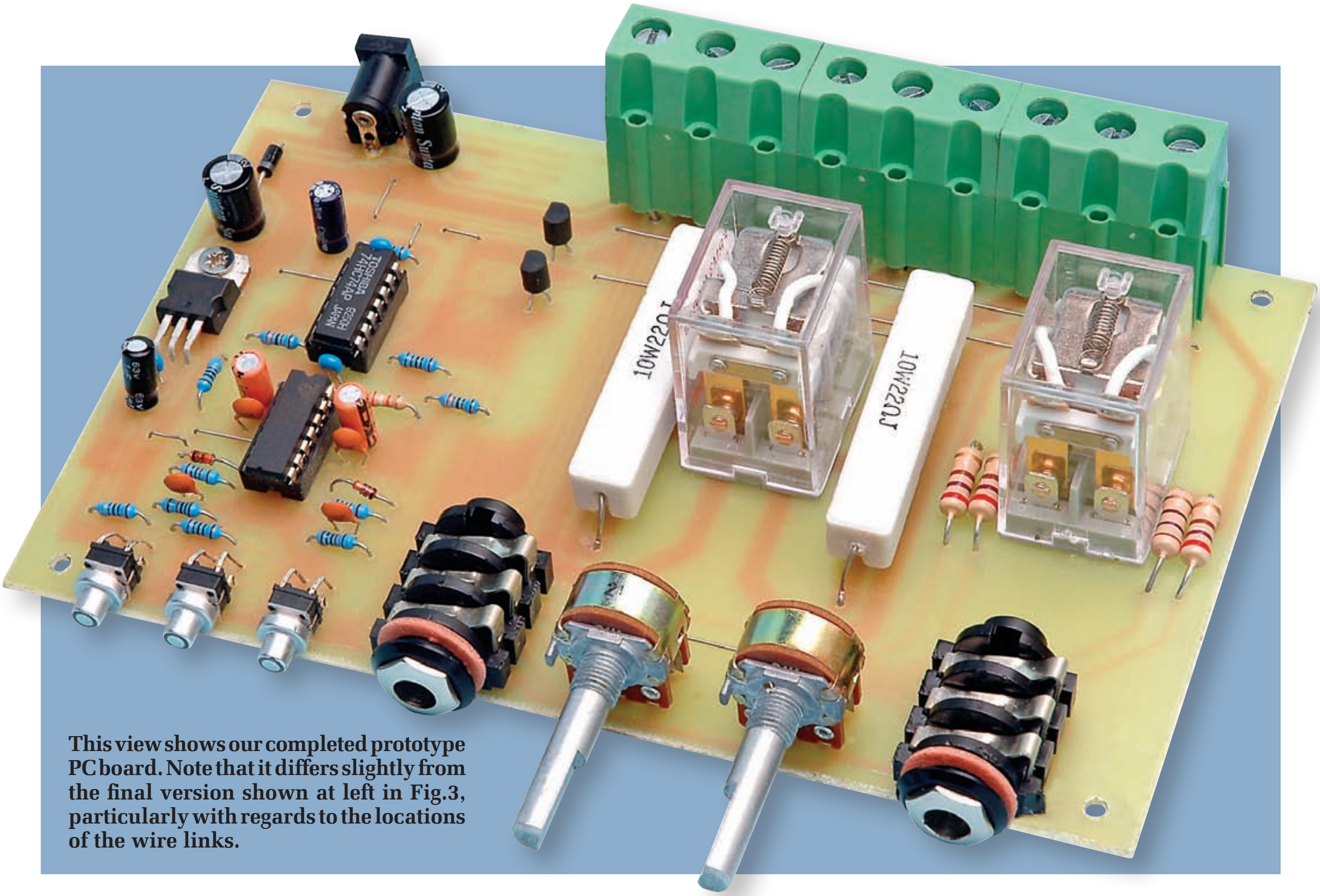
Diodes D4 and D5 are there to ensure that IC1's trigger inputs (pins 6 and 8) cannot go more than 0.6V above the +5V supply rail. What happens is that when a switch is pressed, the relevant 10nF capacitor quickly charges to +5V via a 10kΩ resistor (ie, one side of the capacitor is pulled to ground and the other side goes to +5V). When the switch is subsequently released, the side that was at ground is immediately pulled to the +5V rail by another 10kΩ resistor, and so the other side of the capacitor would go to +10V if not for the diode – ie, we would get a brief 10V spike.

Diodes D4 and D5 clip these voltage spikes to +5.6V and thus prevent damage to IC1.

Muting

Switch S1 is the mute (or Reset) switch and is connected directly to the reset inputs (pins 1 and 13) of both flip-flops in IC2. When this switch is pressed, the reset inputs are pulled to ground and the flip-flops are both set with their Q outputs low and their $\overline{Q}$ outputs high.

As a result, transistors Q1 and Q2 and the relays are on, and so the



This view shows our completed prototype PC board. Note that it differs slightly from the final version shown at left in Fig.3, particularly with regards to the locations of the wire links.

headphones and loudspeakers are off. They can then only be turned back on again by pressing switches S2 and S3.

Diodes D2 and D3 are used to quench the high back-EMF spikes that are generated when the relays switch off. This is necessary to protect the relay driver transistors from damage.

Power supply

Power is derived from a 12V DC plugpack. This supply is filtered using a 220μF electrolytic capacitor, and is used to directly power the relay driver transistors and the relays.

The rest of the circuit is powered from a +5V rail, which is derived from a 3-terminal voltage regulator, REG1. Diode D1 provides reverse polarity protection and its output is filtered using a second 220μF electrolytic capacitor before being applied to the input of the regulator. A 10μF capacitor decouples the regulator's output, with additional 100nF capacitors placed close to the supply pins of IC1 and IC2.

Finally, the power LED (inside S1) is powered via a 470Ω current-limiting resistor. This LED is on whenever power is applied.

Construction

Construction is fairly straightforward with all the parts mounted on a single PC board, code 748. This board is available from the *EPE PCB Service*.

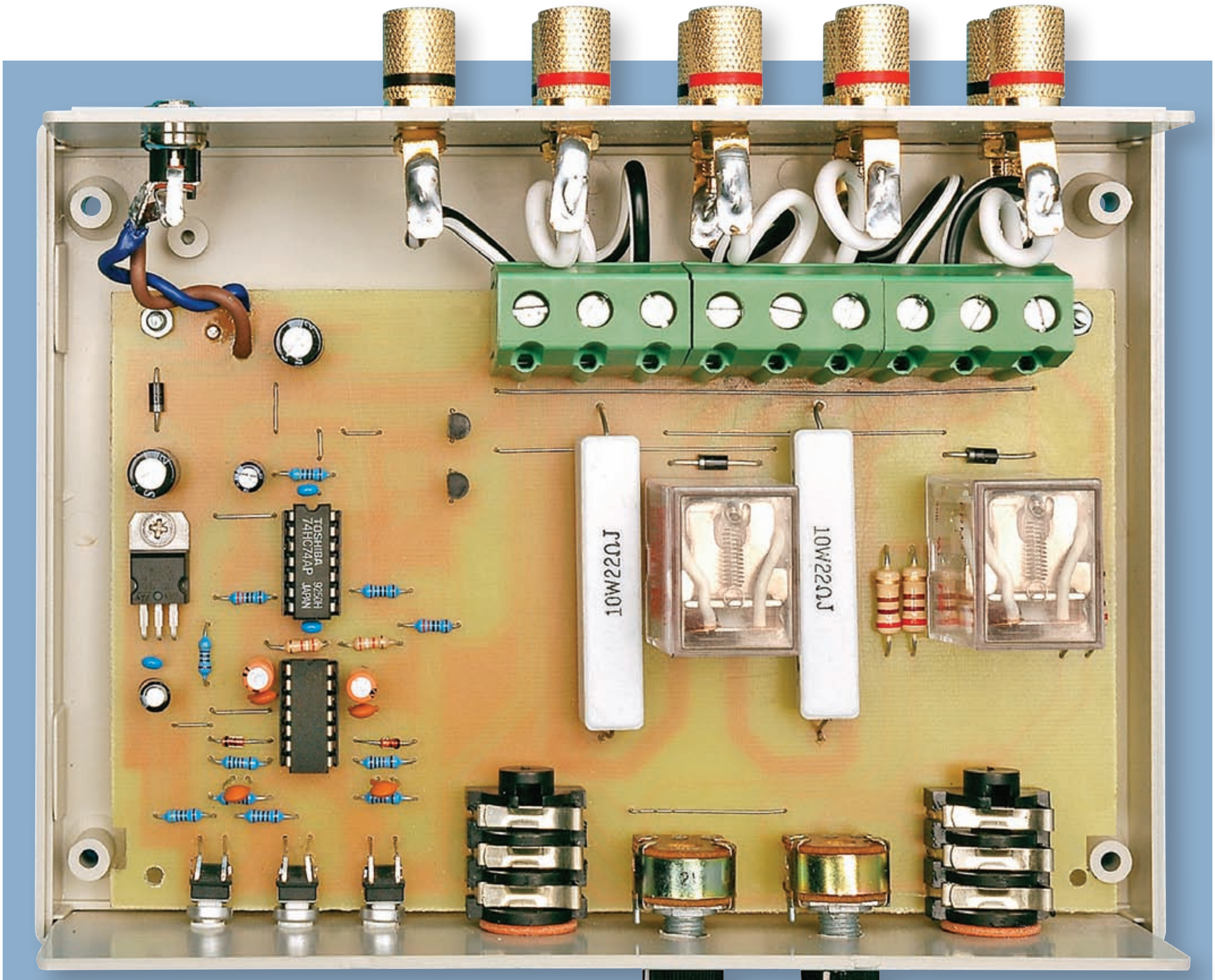
Our prototype was housed in a plastic case measuring 190 × 140 × 50mm. If you intend using this case, it will be necessary to cut out the front corner pieces from the PC board in order to clear the front case pillars.

Fig.3 shows the parts layout on the PC board. Before mounting any parts, check the board carefully for etching defects, then check the hole sizes for the headphone sockets, screw terminal blocks and relays by test fitting these parts into position. Enlarge any holes if necessary.

Begin the assembly by installing the 13 wire links in the positions

Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	2	39kΩ	orange white orange brown	orange white black red brown
❏	4	10kΩ	brown black orange brown	brown black black red brown
❏	2	2.2kΩ	red red red brown	red red black brown brown
❏	3	470Ω	yellow violet brown brown	yellow violet black black brown
❏	4	270Ω	red violet brown brown	red violet black black brown
❏	2	100Ω	brown black brown brown	brown black black black brown
❏	2	22Ω	NA	NA



As shown here, it's necessary to notch (or cut out) the front corners of the PC board to clear the case pillars. The wiring to the binding-post terminals on the rear panel is run using heavy-duty speaker cable.

indicated. These links should all be run using tinned copper wire and must be straight.

To straighten the link wire, simply clamp one end in a vice and then stretch the wire slightly by pulling on the other end with a pair of pliers. Each link can then be cut to length and its end bent down at right angles before installing it on the PC board.

Note particularly that LK4 goes under IC1, while LK9 runs directly behind the screw terminal blocks.

That done, install the resistors and diodes D1 to D5, but leave the 22Ω 10W resistors out for the time being. Table 1 shows the resistor colour codes, but you should also check each one using a digital multimeter.

Take care with the orientation of the diodes and note that D1 to D3 are type 1N4004 while D4 and D5 are type 1N4148. Note also that D4 and D5 face in opposite directions.

The 7805 3-terminal voltage regulator is next on the list. As shown, it's installed with its metal tab flat against the PC board and its leads bent down through 90° to go through their respective holes.

To do this, first position the device on the board, then use a pair of needle-nose pliers to grip the leads at the appropriate point and bend the leads down by 90°. The device's metal tab can then be fastened to the board using an M3 × 6mm screw, nut and lockwasher and the leads soldered.

Do not solder the leads before bolting down the metal tab. If you do this, you could crack the soldered joints as the tab is bolted down.

The capacitors are next on the list. Start with the monolithic and ceramic types, then install the six electrolytics. Make sure that the latter are all installed with the correct polarity.

Next, install the two 22Ω 10W resistors. These should both be mounted 3 to 4mm proud of the PC board to allow air to circulate beneath them for cooling. A couple of thick pieces of cardboard can be used to achieve an even spacing.

Now for the ICs and transistors. Push the transistors down onto the board as far as they will comfortably go before soldering their leads and be sure to use the correct IC at each location. Make sure also that each IC is correctly oriented and be careful not to create unwanted solder bridges when soldering their pins. We strongly recommend you use IC sockets here if you do not wish to solder IC pins directly to the circuit board; prolonged heat on the pins can damage ICs.

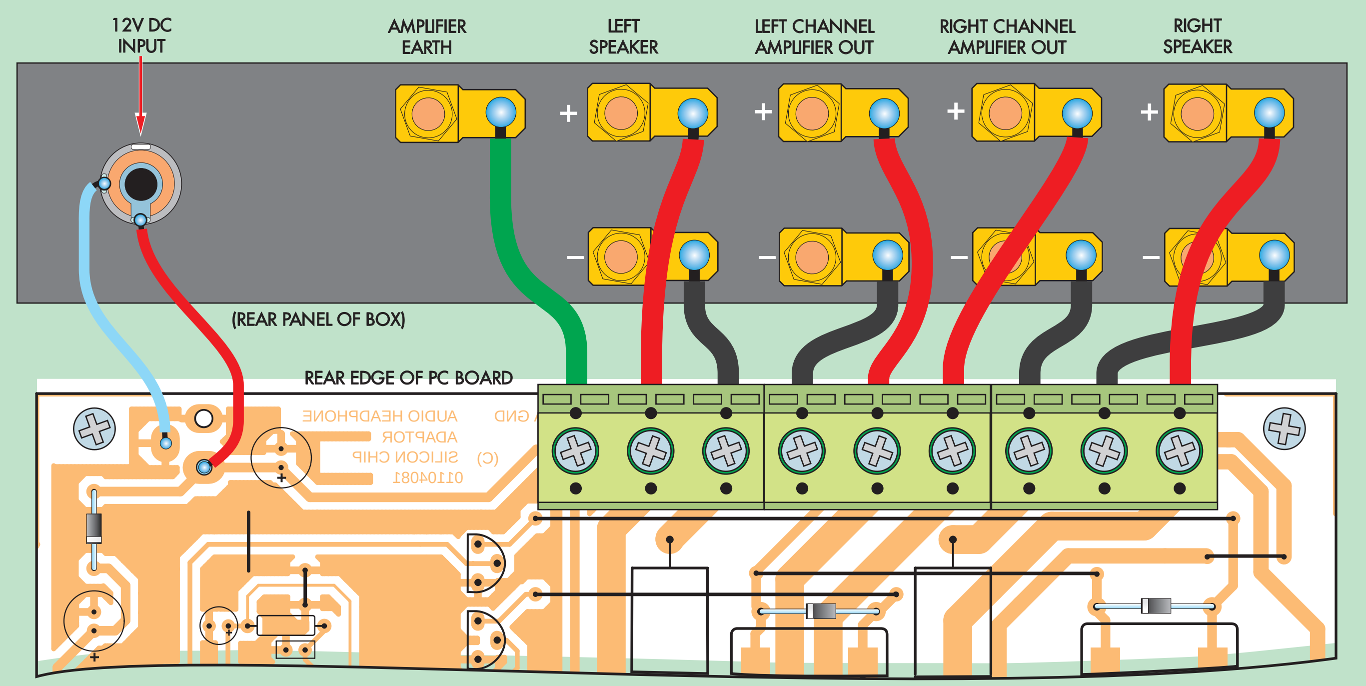


Fig.4: follow this diagram to complete the wiring between the PC board and the rear panel hardware. Note that the leads to the loudspeaker and amplifier terminals should be run using heavy-duty speaker cable.

Finally, the board assembly can be completed by mounting the larger hardware items. These include the two dual (stereo) log. potentiometers, the headphone sockets, the relays and the three 3-way screw terminals blocks. **Cut the pot shafts to about 15mm long before fitting them and make sure that each part is seated correctly against the PC board before soldering its leads/tags.**

The DC power socket should also be installed unless you are mounting the board in a case and intend using a panel-mount DC socket instead.

Testing

Before applying power, go over the board and carefully check your work. In particular, check that the correct part has been used at each location, that all polarised parts are correctly oriented and that there are no missed solder joints or solder 'bridges'.

Once you are satisfied that all is correct, connect a 12V DC plugpack, switch on and check that all three LEDs in switches S1 to S3 light. Check also that the relays remain off at switch-on.

Now press the phones switch (S2) and check that relay RLY2 toggles. At the same time, the green LED in S2 should go out. Pressing this switch again should toggle RLY2 off again and turn the green LED back on.

Finally, check that RLY1 and the blue LED alternately toggle on and off each time the speakers switch (S3) is pressed.

If the module passes all these tests, then it is working correctly. If not, then you're in for a spot of trouble-shooting. Here's what to look for if it doesn't work:

1) Symptom: no LEDs light when power is applied.

Do this: check the supply polarity. If that's correct, check the orientation of diode D1 and check for +5V at the output of regulator REG1.

2) Symptom: all LEDs initially light, but one relay refuses to toggle when its switch is pressed.

Do this: check that the corresponding Q output from IC2 toggles correctly (ie, between 0V and about +4.8V) each time the switch is pressed. If it does, then check the relevant transistor – its collector (C) should toggle high or low each time the switch is pressed.

If the transistor is switching correctly but the relay doesn't operate, check that the diode across the relay coil is correctly oriented.

3) Symptom: a Q output from IC2 does not toggle when the relevant switch is pressed.

Do this: check IC2 and IC3 for correct placement and orientation and check that their pins are all soldered correctly. Check also that diodes D4 and D5 are the right way around (note: these two diodes face in opposite directions).

If you have a scope, check the relevant output (pin 5 or 9) from IC1 – you should see a 0.5s positive-going pulse each time the switch is pressed. Check that this pulse is being applied to the corresponding clock input of IC2.

If there are no pulses from IC1, check the parts associated with the switches at the trigger inputs to this IC. The IC itself may also be faulty (unlikely).

Final assembly

Now for the final assembly. If you are building the unit from a kit, the case will probably be supplied pre-drilled with screen-printed front and rear panels. If not, then you will have to drill the panels yourself using the front and rear panel artworks (Fig.5 and Fig.6) as templates.

The best approach is to first centre-punch the hole locations, then drill each one using a small pilot drill before enlarging it to the correct size. The larger holes (ie, for the headphone sockets, the pots and the DC socket) should be initially drilled to about 5mm, then carefully enlarged to size using a tapered reamer.

That done, colour copies of the panel artworks can be attached to the

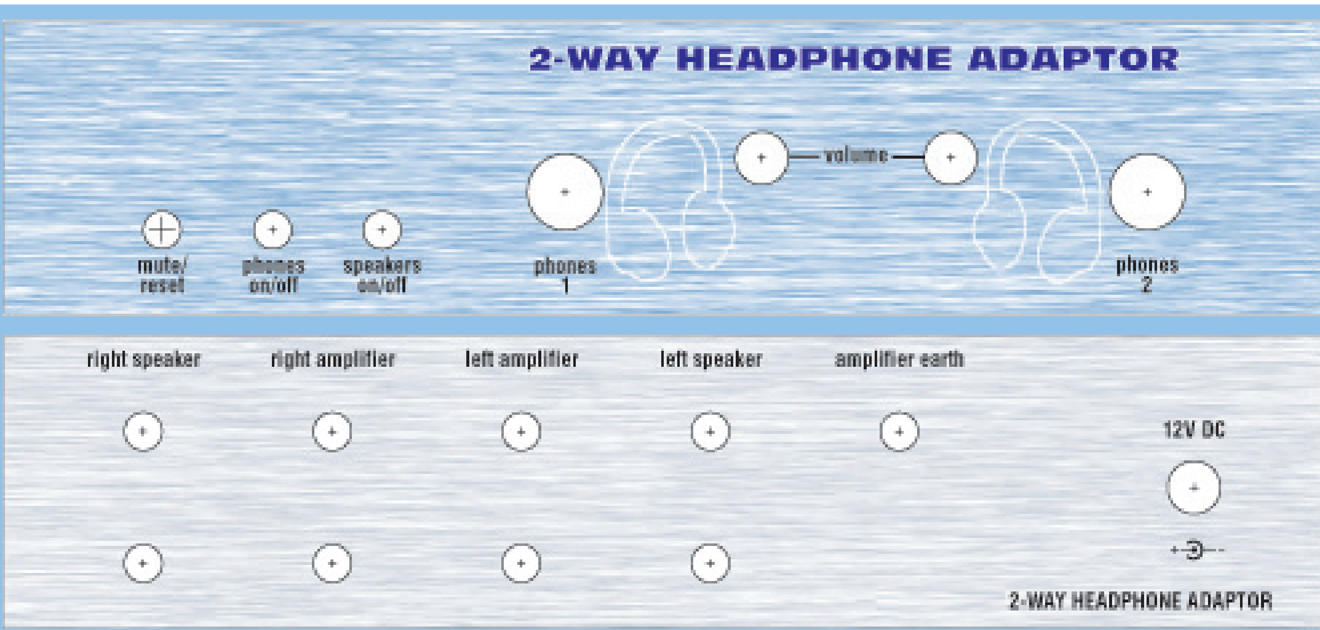


Fig.5 and Fig.6: these two full-size artworks can be used as drilling templates for the front and rear panels.

drilled panels using an even smear of silicone sealant and the holes cut out using a very sharp hobby knife.

Next, fit the front panel to the module and secure it by doing up the nuts for the two headphone sockets. Similarly, fit the panel-mount DC socket and the nine gold-plated binding-post terminals to the rear panel.

Now drop the PC board and front panel assembly into the case and mark out the locations in the base for the rear corner mounting holes. Remove the board and drill these two holes to 3mm, then mount two tapped 6mm spacers in these positions, securing them using M3 × 12mm machine screws which pass up through the bottom of the case.

That done, solder a couple of 50mm long medium-duty hook-up leads to the power supply pads on the PC board. The board assembly can then be secured in place and the wiring to the rear panel completed as shown in Fig.4.

Be sure to use extra heavy-duty speaker cable (eg, 32/0.20) for all connections between the speaker binding-posts and the screw terminal blocks. The lead to the amplifier earth terminal can be run using medium-duty hook-up wire. You can then complete the assembly by fitting the knobs to the pot shafts and attaching the case lid.

Trying it out

As already mentioned, this unit connects in series between the amplifier outputs and the loudspeakers, so disconnect the loudspeaker leads from the amplifier and connect them to the Stereo Headphone Adaptor instead.

The outputs from the amplifier then connect to the left and right channel input terminals on the adaptor.

Finally, connect a lead from the terminal marked 'amp earth' to the amplifier's chassis.

If your amplifier doesn't have a ground terminal, then it may be possible to attach a solder lug under one of the case screws. Alternatively, the earth lead can go to the 'negative' terminal of ONE of the amplifier output channels (but not to both, otherwise you'll get an earth loop and lots of hum). This can be done by connecting an insulated wire link between the 'amp earth' terminal and the 'left amp –' terminal on the back of the Stereo Headphone Adaptor.

After that, it's just a matter of switching everything on, plugging in your headphones and trying it out. ***EPE***

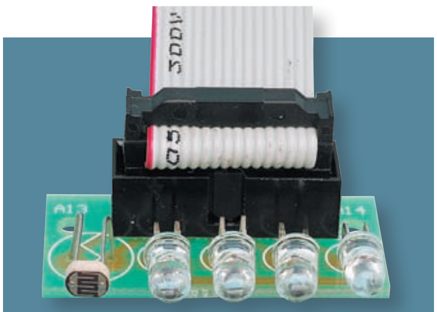
The completed 2-Way Stereo Headphone Adaptor, it can be used with both valve and solid-state amplifiers.

By JOHN CLARKE

Shift Indicator and Rev Limiter For Cars

If you drive your car for optimum performance, you will want this Shift Light Indicator to indicate just when to change gears. As a bonus, it incorporates a Rev Limiter which throttles back the fuel injectors.

IF YOU'RE interested in driving your car for best acceleration or fuel economy, you will know that an engine's torque peaks at a lower RPM than the peak power. You will also know that when driving for maximum fuel economy, it is wise to keep engine revs reasonably low and to get into the highest gear as soon as possible.



The gear shift and rev limit points are indicated by four LEDs. The LDR at far left is part of the dimming circuit.

But whether you are driving for best acceleration or economy, you don't want to be watching the tacho to judge each gear change. That would distract your attention from the road. Having a Shift Light Indicator is the way to go. You will see LEDs light up without having to divert your eyes from the road.

Our Shift Light Indicator has three LEDs to indicate shift points, plus a fourth LED for the Rev Limiter. How you set the individual LED RPM values is up to you. For example, you could set the three LEDs to give a 'ready', 'set' and 'go' indication for each gear change.

Rev limiting can be hard or soft. Hard limiting simply switches off power to the fuel injectors and the engine immediately 'dies'; power does not came back until the RPM falls below a threshold value. Soft limiting reduces the fuel injector duty cycle in stages so that the power is not killed abruptly. Either way, the engine is protected from damage due to over-revving.

Note that many cars these days already have inbuilt rev limiting, so you may choose not to implement this feature.

Connections

The Shift Light Indicator (SLI) can either connect to the tachometer signal from the car's ECU (engine control unit) or to the ignition coil where there is no ECU. We have catered for just about every conceivable engine configuration: 1 to 12-cylinder 4-stroke, 1 to 6-cylinder 2-stroke, and 2 and 3-cylinder asymmetrical 4-stroke.

Other connections required are +12V power, 0V (chassis), ground and to the fuel injectors.

The SLI unit can be located in a convenient location under the car's

dashboard, while the separate display involving four high brightness LEDs can be mounted on the dashboard. The shift LEDs have automatic dimming so that they will not be too bright when driving at night, but the Rev Limiter does not have dimming – so when it comes on, you will be fully alerted!

Shift points

Each shift point can be set and operates independently from the others. While the software has them labelled as Shift1, Shift2 and Shift3, they can each be set anywhere between 0 and about 12,500RPM, in 25RPM steps.

Setting shift points is easy and is done with a trimpot that produces a voltage directly proportional to RPM. So, if a shift point is required at 5500RPM, you set the trimpot wiper to 0.55V. You then press a switch to store the value.

The Shift LEDs light to indicate RPM at and above the stored values, as shown in Fig.1. An adjustment is provided to prevent them from flickering on and off when the RPM is hovering around the shift point. This adjustment causes the Shift LEDs to go out at an RPM lower than the shift setting. The difference in the thresholds is called the 'hysteresis'.

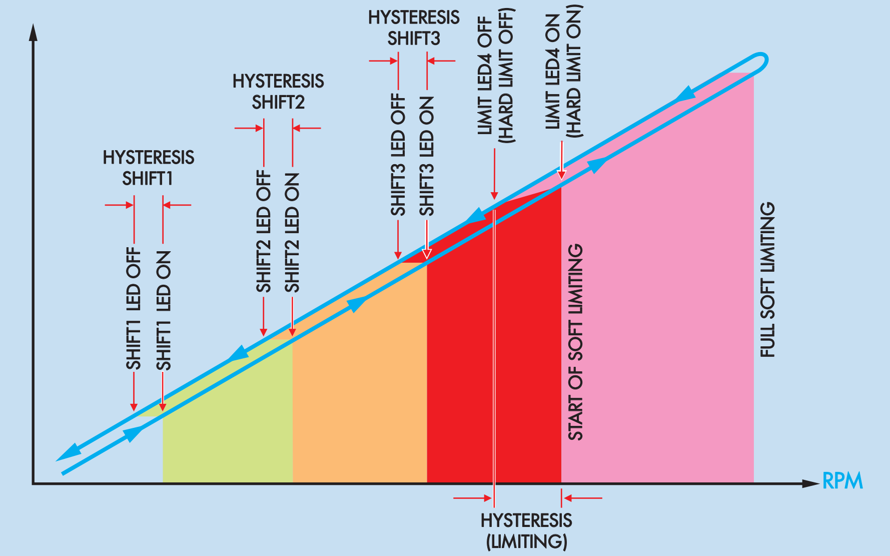


Fig.1: this diagram shows how the shift LEDs light to indicate RPM at and above the stored values. Note that a degree of hysteresis is built into each shift point, to prevent LED flicker at the critical values.

Measuring engine revs

We measure engine revs in RPM (revolutions per minute) by monitoring the tachometer signal from the car's ECU. This delivers one pulse for every cylinder firing (ie, each spark plug firing). We also need to know the engine type (2 or 4-stroke) and the number of cylinders in order to calculate engine RPM. For example, a 4-cylinder 4-stroke engine has two cylinder firings per revolution, a 6-cylinder has three firings, a V8 has four firings per rev, and so on.

A particular problem in measuring engine RPM is that we cannot just count pulses over a one minute or even a ten second period. That would mean that the SLI just would not react fast enough. Instead, we could use a 300ms period, which gives a count of 10 for a 4-cylinder 4-stroke engine running at 1000RPM.

But even this period is too long when you consider how fast engine RPM could change – it could easily go from 1000RPM to 6000RPM or more, in that short time. In addition, a counting period of just 300ms means that the RPM cannot be measured accurately. That previous count of 10 pulses might mean the RPM is 900 or 1100RPM, a 200RPM uncertainty – not very good.

There is a better way, as shown in Fig.2, the block diagram of the circuit. Here the RPM signal from the engine is filtered to prevent triggering on transient signals and then instead of counting the pulses, we measure the time between them, using a 2MHz signal. What happens is that each firing pulse gates the 2MHz signal to a counter. The

How rev limiting is achieved

THIS project achieves rev limiting by cutting power to the fuel injectors, and this involves switching the injector positive (+12V) supply rail. This can be done using one of two methods – either by using a relay to switch the supply for hard limiting, or by pulse width modulating power MOSFETs to give soft limiting – ie, a gradual reduction in engine power.

Fig.7(a) shows the standard fuel injector setup. As can be seen, the positive terminals of the fuel injectors are all connected to a common +12V supply rail. The engine management unit computer (ECU) switches the negative side of each injector.

Hard limiting is achieved by wiring the relay in series between the positive terminals of the fuel injectors and the +12V injector supply rail. This relay, which is controlled by the limiter circuit, switches off the injectors (by opening its contacts) when the rev limit is reached and this immediately cuts engine power. Fig.7(b) shows this scheme.

Alternatively, soft limiting is achieved by wiring two parallel power MOSFETs in series between the fuel injectors and the +12V injector supply rail. These MOSFETs are then pulse width modulated (PWM) by the limiter circuit when the rev limit is reached, which means that the injector supply rail is also pulse width modulated.

The higher the revs go, the lower the PWM duty cycle. As a result, the engine power is gradually reduced when the rev limit is reached. Fig.7(c) shows this scheme.

Why do we also include the relay in the soft limiting circuit? It's there for added reliability, as explained in another panel.

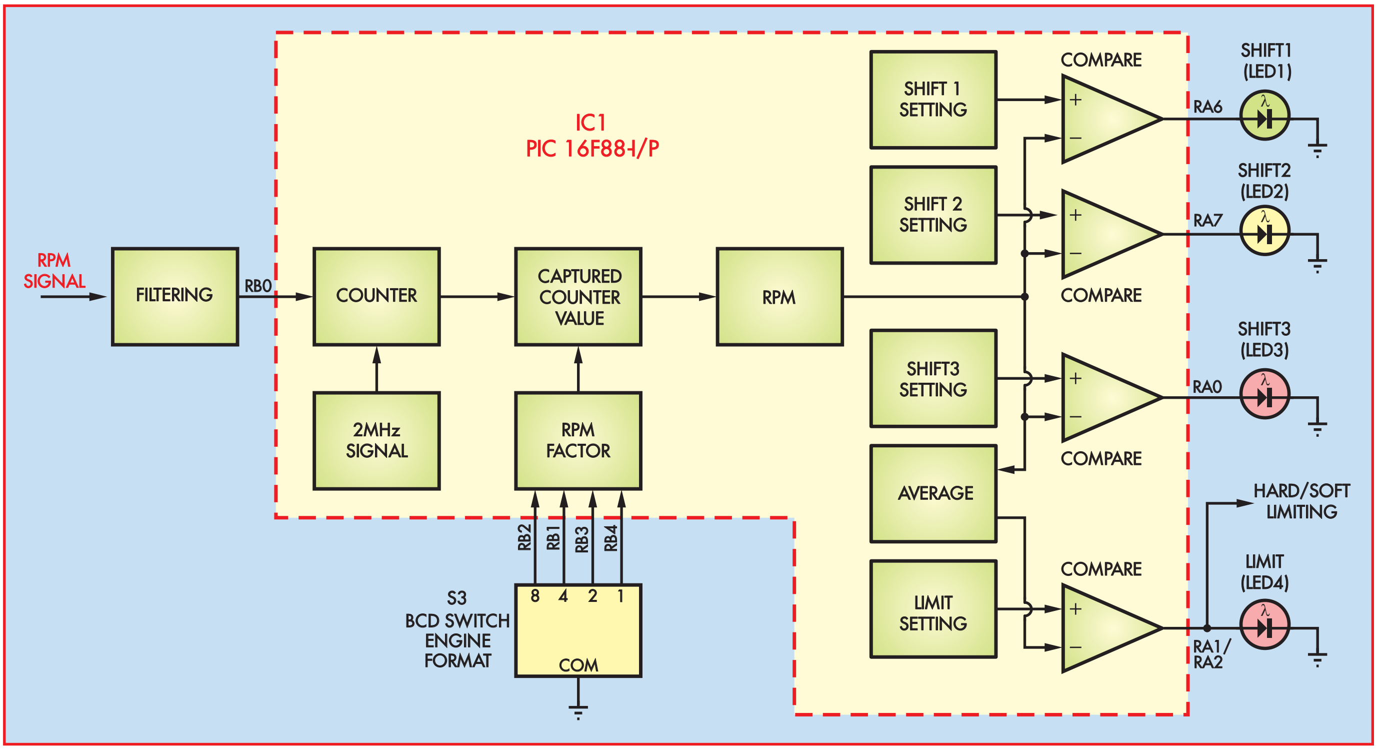


Fig.2: block diagram of the Shift Indicator and Rev Limiter. It measures RPM by using the tacho signal to gate a 2MHz signal into a counter. The counter value is then divided into the RPM factor, as set by BCD switch S3, to give engine RPM.

next pulse places the count in memory and clears the counter, which then proceeds to count again.

For example, if the RPM signal is 33.333Hz, then the counter will reach 60,000 between pulses. This value is divided into the RPM factor, which for a 4-cylinder 4-stroke engine is 60 million. So in this case, the result of the division is 1000RPM.

Each RPM calculation takes 888μs; well before a new count is available. This RPM value is then compared against the settings for shift1, shift2 and shift3.

Circuit description

The full circuit diagram for the Shift Indicator and Rev Limiter for Cars is shown in Fig.3. It is based on IC1, a PIC16F88-I/P microcontroller which monitors the RPM signal. It then makes the RPM calculations and comparisons with the 'set shift' and 'limit levels', and drives the associated LEDs and limiting circuitry. IC1 operates at 8MHz and is powered from a 5V supply derived from a 3-terminal voltage regulator, REG1.

Two RPM signal input options are provided: either from the ignition coil negative terminal (HI) via a 22kΩ resistor, or the nominal 5V signal from the ECU (LO). The ignition coil signal is filtered using one or two 47nF capacitors (LK1 adds the second capacitor) and then AC-coupled via a 2.2μF capacitor to the next stage comprising a 100kΩ resistor and 16V Zener diode clamp (ZD2). Diodes D5 and D6 clamp the signal between +5.6V and –0.6V before it is fed to the RB0 input at pin 6 of IC1.

The inputs that connect to the BCD switch (S3) and to the Select (S1) and Set (S2) switches are normally pulled to +5V via internal resistors. When the respective switch is closed, its input is pulled low.

Switches S1 and S2 are continuously monitored by IC1.

Engine selection

BCD switch S3 selects the engine type. This has four switches (at RB4, RB3, RB1 and RB2) and provides 16 possible combinations, ranging from all switches open to all closed.

The settings for S3 are checked by IC1 when it is first powered up; this sets the required engine type for RPM calculations.

Trimpot VR1 provides the RPM values for the shift and limit settings. The series 30kΩ and 10kΩ resistors connected to the trimpot's wiper reduce the maximum voltage at TP1 to 1.25V.

In practice, VR1 is adjusted to provide the desired RPM voltage at TP1 and 1V is equivalent to 10,000RPM. So, to set the RPM to 5500RPM, VR1 is adjusted so that the voltage at TP1 is 0.55V.

Trimpot VR2 sets the hysteresis range for each shift and limit setting. A 5V setting at TP2 provides 500RPM hysteresis and 1V gives 100RPM hysteresis.

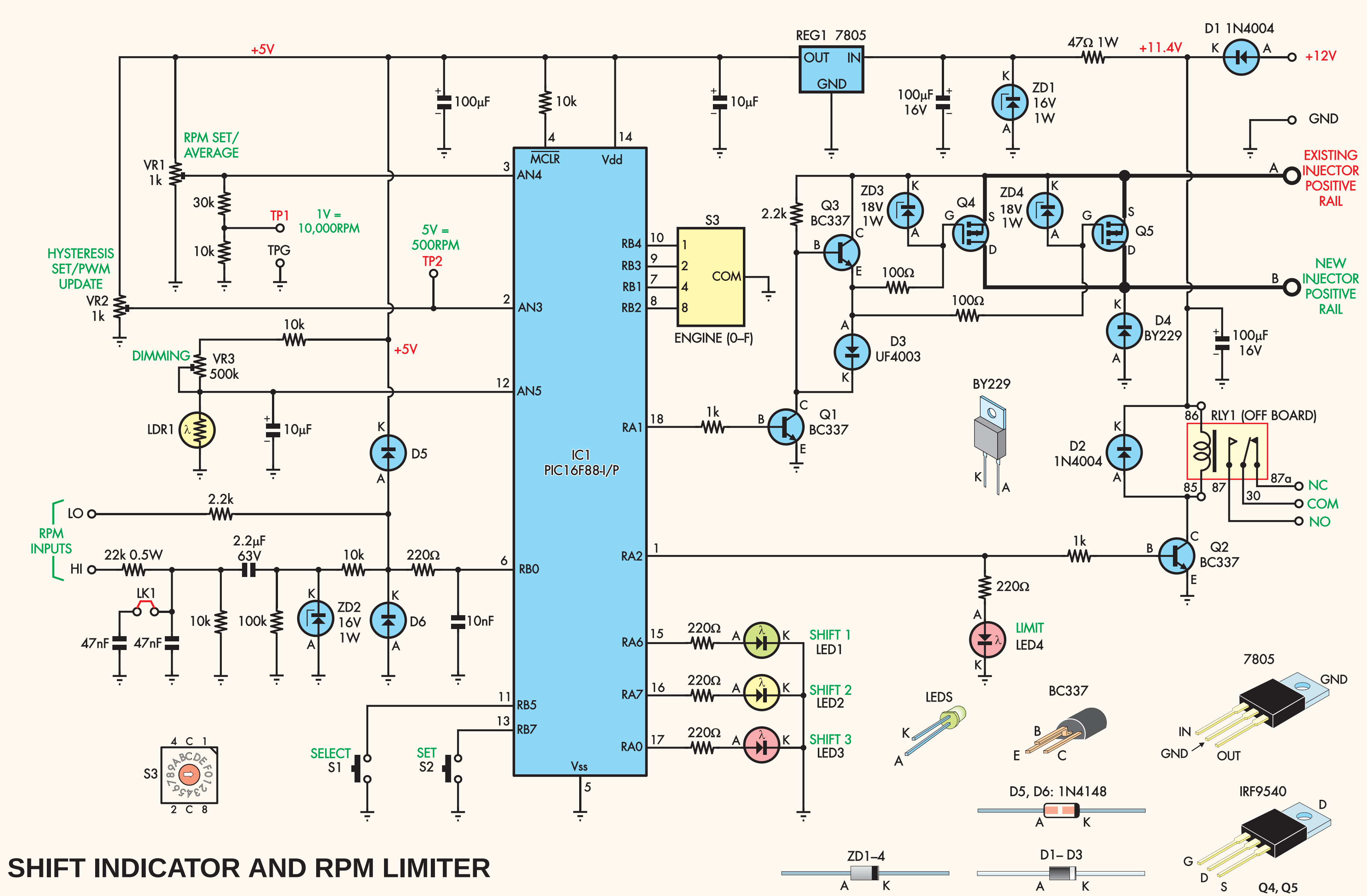
Trimpot VR3 sets the ambient light threshold for dimming the LEDs. The LEDs are bright enough to be easily seen in daytime driving, and therefore need to be dimmed for night-time driving. The ambient light is monitored by a light-dependent resistor (LDR1) and it is connected in series with a 10kΩ resistor and trimpot VR3 to provide a voltage at IC1's AN5 input.

The 10μF capacitor at the AN5 input averages out changes in ambient light. This prevents the display rapidly changing in brightness if passing along a street-lit area at night.

Dimming is achieved by driving the LEDs with a duty cycle that can be varied from 1.56% through to 100% (full brightness) in 63 steps.

Microcontroller outputs

Apart from the three shift LED outputs at pins 15, 16 and 17, there are two rev-limiting outputs at pins 18 and 1 (RA1 and RA2). Pin 1 (RA2) drives transistor



SHIFT INDICATOR AND RPM LIMITER

Fig.3: the circuit is based on PIC16F88-I/P microcontroller IC1. This stores the shift and limit settings and compares these against the incoming RPM signal that's fed to its RB0 input at pin 6. IC1 then drives shift LED1 to LED3 at its RA6, RA7 and RA0 outputs accordingly. The RA1 output drives the soft-limiting circuitry (Q1, Q3, Q4 and Q5), while RA2 drives relay RLY1 via Q2 to provide the hard limiting option.

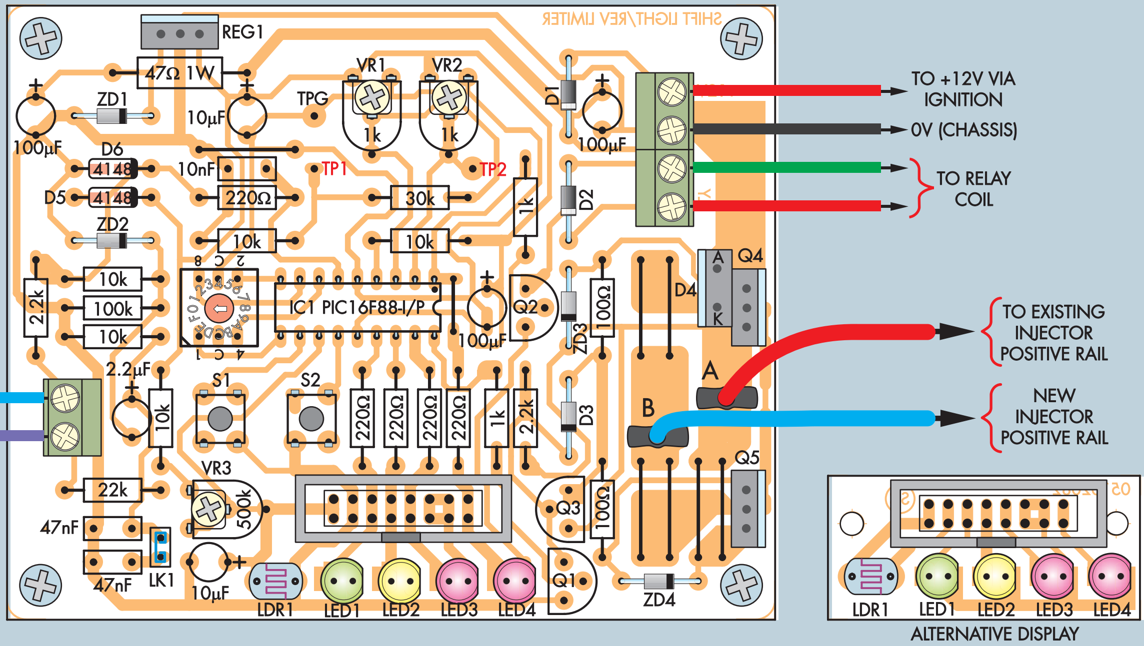


Fig.4: install the parts on the PC board as shown on this component layout diagram. You can either mount LED1 to LED4 and the LDR on the main board as shown, or you can mount these parts on a separate display PC board (shown at bottom right). The two boards are connected together via a 16-way ribbon cable fitted with IDC line plugs.

Q2, and this in turn drives an external relay (RLY1) for the hard limiting function. Diode D2 clamps any back-EMF spikes produced by the relay's coil when the transistor is switched off.

Pin 18 (RA1) drives transistor Q1 and this then drives the gates (G) of *P*-channel MOSFETs Q4 and Q5 for the soft-limiting function. Q4 and Q5 control the positive supply to the motor's fuel injectors, and this can be progressively reduced by varying the duty cycle of the pulse width modulation drive.

In operation, *P*-channel MOSFETs Q4 and Q5 provide 'high side' switching of the injector supply rail. Normally, the RA1 output pin is set high to turn on transistors Q1, Q4 and Q5 so that the injectors are fully powered. Above the set RPM limit, IC1's RA1 output (pin 18) will switch MOSFETs Q4 and Q5 with a duty cycle which is reduced gradually until there is no injector drive once the motor is over the set limit. The pulse frequency to the injectors is 30.5Hz.

MOSFETs Q4 and Q5 are driven in the following way: when Q1 is switched off, the base (B) of transistor Q3 is pulled high via a 2.2kΩ resistor to +12V. This turns on Q3, and so its emitter (E) pulls the gates of Q4 and Q5 towards the +12V supply and switches them off.

However, when Q1 is switched on, Q3 is switched off, and its emitter is pulled down to 0V via diode D3. This pulls the gates of Q4 and Q5 low and switches them on.

Diode D4 is included to protect Q4 and Q5 from the back-EMF spikes produced by the injectors when they turn off.

Power supply

Power for the circuit is derived from the vehicle's +12V rail via diode D1. This provides protection if the supply is connected the wrong way around. A 16V Zener diode (ZD1) clamps any spike voltages which may occur on the battery supply, and further filtering is provided by the 100µF capacitor for the supply to REG1, a 7805 5V regulator.

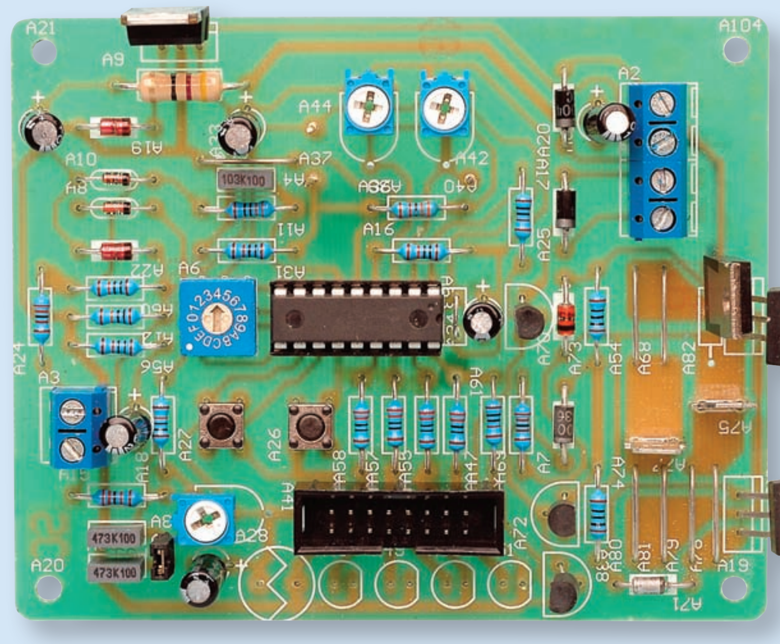
The 5V rail from REG1 is used to power IC1.

Software

The software files are available via the *EPE* Library site, accessed via **www.epemag.com**. Pre-programmed

Table 1: Resistor Colour Codes

❏	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❏	1	100kΩ	brown black yellow brown	brown black black orange brown
❏	1	30kΩ	orange black orange brown	orange black black red brown
❏	1	22kΩ	red red orange brown	red red black red brown
❏	5	10kΩ	brown black orange brown	brown black black red brown
❏	2	2.2kΩ	red red red brown	red red black brown brown
❏	2	1kΩ	brown black red brown	brown black black brown brown
❏	5	220Ω	red red brown brown	red red black black brown
❏	2	100Ω	brown black brown brown	brown black black black brown
❏	1	47Ω 1W 5%	yellow violet black gold	not applicable



Make sure that all polarised parts are correctly oriented when installing them on the board. The locating slot in the IDC header goes towards the bottom edge. Don't install the IC until the supply has been fully tested.

PICs will also be available from Magenta Electronics – see their advert in this issue for contact details.

Construction

The Shift Light Indicator is built on a PC board, code 749 Main (101 × 81mm), while a separate display board, code 750 Display (42 × 19mm) carries the display LEDs. Alternatively, the LEDs can be mounted on the main board. These boards are available as a set from the *EPE PCB Service*.

If you choose to use the separate display board, it's connected back to the main board via a 16-way ribbon cable fitted with IDC headers (Fig.6).

As usual, begin construction by checking the PC board for any defects such as shorted tracks and breaks in the copper. That done, check that the hole sizes are correct. The holes for the four corner mounting screws need to be 3mm in diameter, while the holes for the screw terminal blocks need to be 1.2mm.

Check also that the PC board fits into the box. If it doesn't fit, use a small file to round the corners until it does.

Fig.4 shows the parts layout on the PC board. Start the assembly by installing the wire links, followed by the resistors. Table 1 shows the resistor colour codes, but you should also check each one using a digital multimeter before installing, as some colours can be hard to read.

Next, install the PC stakes for 'test points' TP GND, TP1 and TP2. That done, install the 2-way header for link LK1.

Follow these with the diodes and Zener diodes, taking care to install each with the correct orientation. Once these parts are in, install a socket for IC1 with its notched end towards Q2. Don't install the IC yet – that step comes later.

The capacitors can go in next, again taking care to ensure that the electrolytics are correctly oriented. That done, install transistors Q1 to Q5 and regulator REG1.

Note that REG1, Q4 and Q5 mount with their leads protruding through the bottom of the PC board by about 1mm. Later, this will leave sufficient lead length to allow the devices to be fastened to the side of the box.

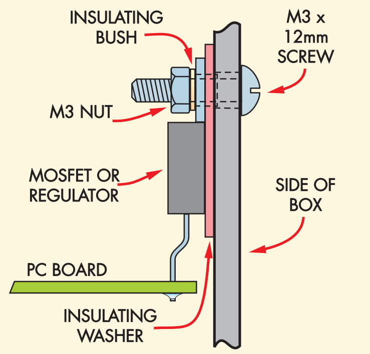


Fig.5: the mounting details for REG1 and MOSFETs Q4 and Q5. Each device is electrically isolated from the case using an insulating washer and bush (see photo).

Now install the trimpots and the BCD switch (S3). The correct orientation for S3 is with its corner dot to the lower left – see Fig.4. Switches S1 and S2 can now be inserted. These two switches will only fit on the PC board with the correct orientation.

The next step is to mount the two 6.8mm PC spade terminals, the 16-way IDC cable socket and the screw terminal blocks. Note that the 4-way terminal block consists of two 2-way blocks that are joined by sliding their moulded dovetails together.

Display board assembly

Fig.4 also shows the display board assembly. It should only take a few minutes to assemble.

There are a couple of options here when it comes to mounting the LEDs and the LDR. One option is to bend the LED leads at right angles about 8mm from their bodies, and install them so that they sit at right angles to the PC board, as shown in the photo on the first page.

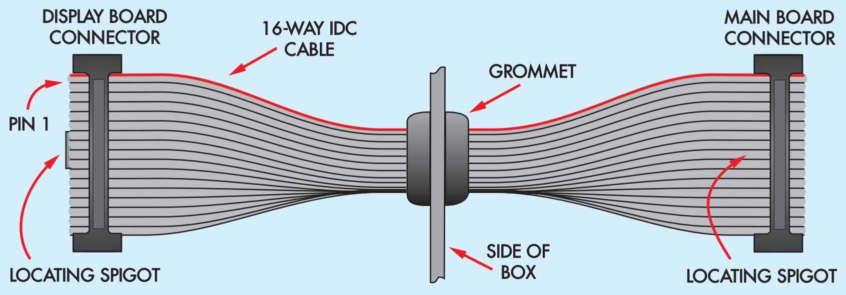


Fig.6: here's how to make up the IDC cable that connects the display board to the main board. The header plugs can be clamped together using a small vice. Note the positions of the locating spigots on the plugs.

Features and specifications

Features

- Three independent shift indicator LEDs
- One RPM limit LED
- Adjustable hysteresis for each shift setting and at the limit
- Relay switching of injectors at limit (hard limiting)
- Alternative soft limiting using pulse width modulation (PWM)
- Suits most petrol engines, including asymmetrical cylinder types
- Automatic dimming of shift LEDs and adjustable minimum brightness
- Easy adjustment of shift and RPM limit settings
- Easy engine selection – suits all engine types from 1 to 12 cylinders
- Easy adjustment of soft-limiting effect

Specifications

RPM accuracy: typically <2% at 25°C with a 5.0V supply.

Maximum shift and limit settings: 12,500RPM for 1 to 12-cylinder 4-stroke engines (1 to 6-cylinder 2-stroke).

Shift and limit RPM adjustment: 0 to >12,500RPM in 25 RPM steps.

Adjustment for RPM using VR1: 1V = 10,000RPM, 0.5V = 5000RPM (5.0V supply).

Hysteresis adjustment: 0 to 500RPM in 2RPM steps

Adjustment for hysteresis using VR2: 1V = 100RPM, 5V = 500RPM (5.0V supply).

Shift and limiting response: RPM dependent (see Table 2). PWM limiting response is slowed using effects.

Soft-limiting PWM: 100% to 0% with a maximum of 250 steps over the hysteresis RPM range at a 30.5Hz rate.

Soft-limiting effects: PWM update after 1-16 PWM cycles, RPM measurement averaging over 1 to 64RPM values.

Dimming of shift LEDs: full range of 63 dimming steps from 1.5625% to 100% using PWM at 122Hz. The 0% PWM is not included. Minimum dimming can be adjusted to any one of the 63 settings.

Similarly, the LDR's leads can be bent at right angles about 11mm from its body before installing it on the board. A 7mm-wide cardboard spacer can be used to ensure that these parts all sit the same distance above the board.

Alternatively, you can push the parts right down onto the board so that the leads touch the board surface. Another option is to mount the LEDs and the LDR on the back of the PC board. It all depends on how you intend to ultimately mount the display board on the dashboard.

Whichever option you choose though, be sure to install each LED with the correct orientation – the anode (A) lead is always the longer of the two. The LDR can go in either way around. Once these parts are in, install the IDC socket.

The other option is to install the LEDs and the LDR on the main PC board. In that case, you will have to later drill matching holes in the side of the case.

Final assembly

A metal diecast case measuring 111 × 60 × 54mm is used to house the main board. This makes for a rugged assembly and provides heatsinking for regulator REG1 and the two power MOSFETs (Q4 and Q5).

The first step here is to drill the four mounting holes in the base for the PC board. That done, fit four 10mm spacers to the case, then mount the board in position and secure it using M3 × 6mm screws and nuts.

Having secured the board, bend the leads for REG1, Q4 and Q5 so that their metal tabs sit flat against the sides of the case. Carefully mark out their tab mounting holes, then remove the PC board and drill these holes to 3mm. Be sure to de-burr each hole using an oversize drill to give a clean, flat surface (this is important to prevent punch-through of the insulating washers when the devices are secured to the case).

In addition, you will have to drill three 9.5mm holes in the side of the case to provide external wiring access. These holes should be opposite (and slightly above) the 2-way and 4-way terminal blocks and the IDC header. Use a small pilot drill to start these holes, then ream them to size and de-burr them before fitting the rubber grommets.

Note: the hole opposite the IDC header is not required if the LEDs and LDR are mounted on the main board. You will, however, have to drill five holes to accept the LED bodies and to allow light through to the LDR.

Reinstalling the board

The PC board can now be reinstalled and REG1, Q4 and Q5 secured to the sides of the case. Note that their metal tabs must be electrically isolated from the case using TO-220 insulating washers and mounting bushes – see Fig.5. Each device is secured using an M3 × 10mm screw and nut.

Once these devices have been secured, use a multimeter to confirm that their metal tabs are indeed isolated from the case.

The IDC cable can now be installed. This is done by first rolling up the cable and feeding it through the hole opposite the IDC socket. The IDC plug can then be attached, making sure that the orientation is correct (see Fig.6). Use a small vice to clamp the header plugs together to secure the cable.

Testing the PC board

The first step in the test procedure is to apply power to the +12V and 0V terminals on the 4-way terminal block. That done, check the voltage between pins 14 and 5 on the IC socket. This should be close to 5V (a range of 4.8V to 5.2V is acceptable).

If the voltage is below 4.8V, check for a short on the PC board. If there is no voltage, check that diode D1 is the right way around.

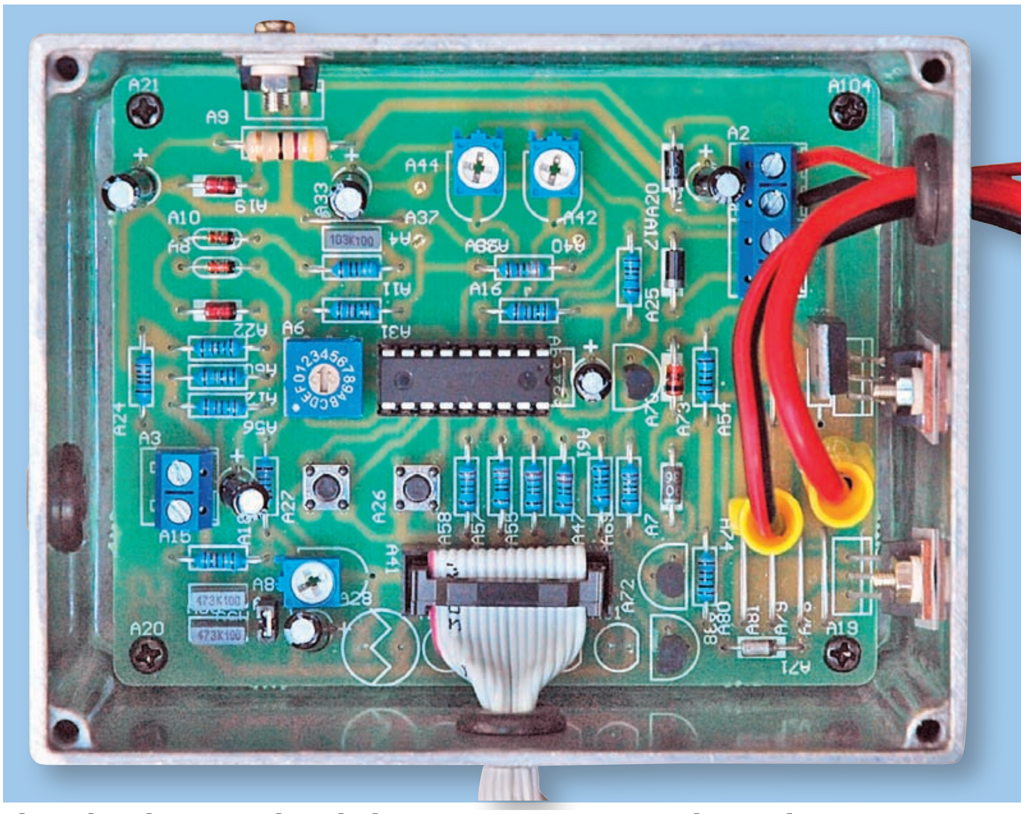
Assuming that everything is correct, switch off and install IC1 in its socket. It must be installed with its notched end towards transistor Q2.

Next, apply power and adjust trimpot VR3 fully clockwise. Now press switch S1 and check that LED1 lights. Repeated pressings should now cause LED2, LED3 and LED4 to light in sequence, with only one LED on at a time. These correspond to the settings modes for Shift1, Shift2, Shift3 and Limit respectively.

If S1 is now pressed again, LED4 (Limit) should remain on while LED1 to LED3 should light up in sequence at a relatively fast rate. This is the soft limiting setting mode for the rev-limiting feature.

Pressing S1 yet again should turn on just LED1, LED2 and LED3. This is the selection for setting the minimum dimming level.

Finally, pressing S1 again should switch all the LEDs off. This returns the unit to its normal mode, whereby each LED lights when the incoming RPM signal reaches its respective threshold.



The PC board is mounted inside the case on 10mm spacers and secured using M3 × 6mm screws. REG1, Q4 and Q5 are then bolted to the case – see Fig.5. Note that the wiring to the fuel injectors is not required if you opt for hard limiting.

Threshold adjustments

As noted already, trimpots VR1 and VR2 are used to set the Shift and Limit thresholds and hysteresis values.

The first step is to set these values for Shift1. The procedure is as follows:

Step 1: press switch S1 so that LED1 lights.

Step 2: attach a multimeter between test point TP1 and TP GND, and adjust VR1 to set the desired RPM threshold. Note that the voltage on TP1 is directly related to the RPM setting, where 1V represents 10,000RPM. To set a 4000 RPM threshold, for example, adjust VR1 for a reading of 0.4V (400mV).

Note also, due to trimpot resolution, that you may not be able to adjust the voltage to better than 5mV (equivalent to 50 RPM) of the desired value.

Step 3: connect a multimeter between test point TP2 and TP GND.

Step 4: adjust VR2 to set the RPM hysteresis value. This can be adjusted from 0-500RPM. Note that 5V at TP2 sets the hysteresis to 500RPM, 4V gives 400RPM, and so on.

Step 5: press Set switch S2 to program the RPM threshold and hysteresis adjustments for Shift1 into IC1. LED1 will now flash five times to indicate that these settings have been saved.

Note: if you require the highest possible accuracy, you will have to scale the adjustment voltages to compensate for REG's output (ie, if this is not exactly +5V). In practice, it's just a matter of multiplying the threshold RPM required by the measured supply voltage and dividing the result by 5V.

For example, let's say that you want to set the RPM threshold to 4000RPM and that the supply voltage is 4.95V. In that case, the calculation is 4000 × 4.95V/5V, or 3960. So, to adjust for 4000RPM when the supply is 4.95V, you must set VR1 to give 0.396V at TP1.

Step 6: press S1 so that LED2 lights and repeat the above steps (through to Step 5) to set the threshold and hysteresis values for Shift2. Repeat this procedure to set the values for Shift3, making sure each time that the correct LED is selected.

Don't forget to press S2 to save the changes each time you adjust VR1 and VR2 for each Shift setting. This must be done before moving on to the next Shift light, otherwise the settings will not be saved.

Rev limit adjustments

Now for the rev limit adjustments. Just follow these steps:

Step 1: press S1 after the Shift3 settings have been saved. This turns LED4 (Limit) on, while all the other LEDs are off.

Step 2: monitor the voltage at TP1 and adjust VR1 to set the rev limit. As before, 1V is equivalent to 10,000 RPM, so to set a limit of 6000RPM, for example, set VR1 for a reading of 0.6V.

Step 3: monitor TP2 and adjust VR2 to set the rev limit hysteresis. In this case, 1V is equivalent to 100RPM.

If you intend using PWM limiting, so that the engine power drops off gradually, use an initial value of 500 RPM (5V at TP2). Alternatively, if you intend using relay limiting, set the value to 200RPM (2V at TP2).

Step 4: press S2 to save these settings.

Step 5: press S1 to bring up the soft limiting adjustment mode – ie, LED4 lit and LED1 to LED3 lighting in sequence.

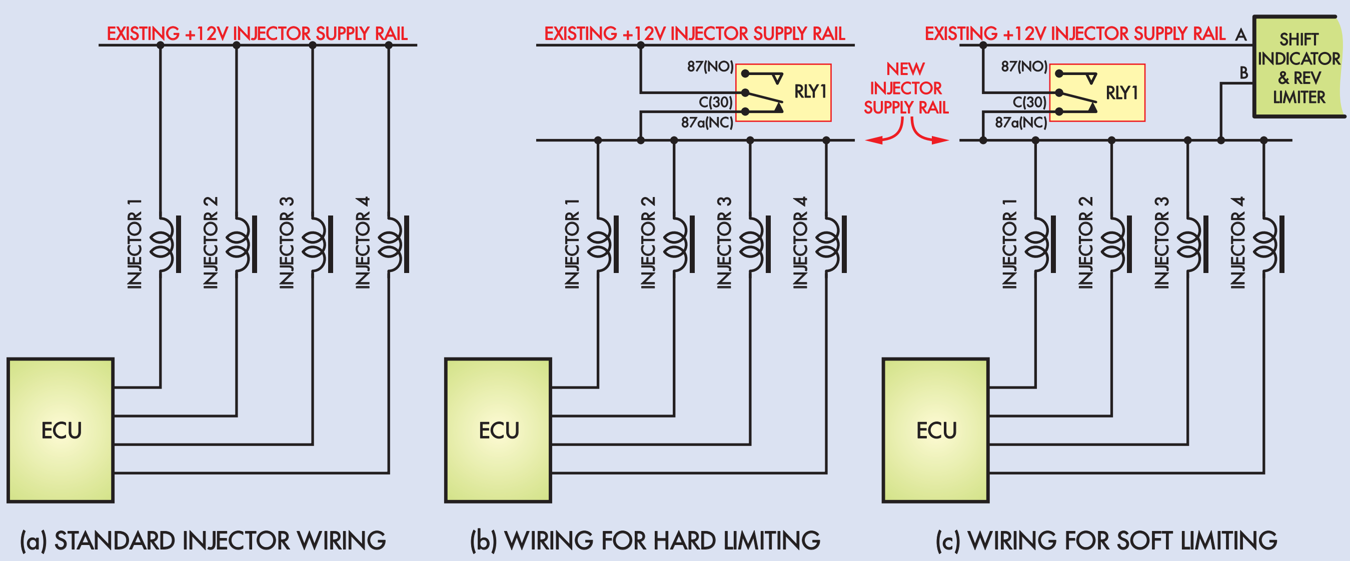


Fig.7: these diagrams shows the standard fuel injector setup (a) plus the modifications required to wire in the limiter circuit for hard limiting (b), or soft limiting (c). Be sure to use a relay with 30A contacts, as specified in the parts list. Note that the relay (RLY1) is used in both the hard limiting and soft limiting circuits – see panel.

Trimpot VR1 now adjusts the number of RPM calculations that are used in averaging the RPM reading, while VR2 adjusts the rate at which the PWM (pulse width modulation) that provides the soft limiting changes.

Setting VR1 fully clockwise gives an average of 64RPM calculations, while setting VR2 fully clockwise gives 16 PWM cycles before changes occur. Conversely, fully anticlockwise settings for VR1 and VR2 give no averaging and a PWM that can change with each cycle.

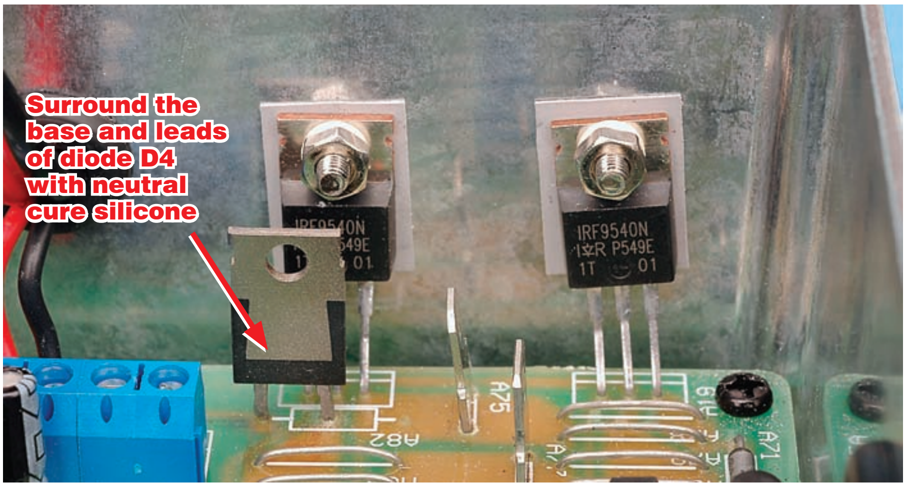
Setting both VR1 and VR2 to midway would provide a suitable soft limiting effect for most engines. However, if the soft limiting subsequently proves to be too soft, so that the engine RPM overshoots the desired limit by a large margin, then the trimpots should be adjusted further anticlockwise.

Note that VR1 has an effect on both the soft limiting smoothness and the response time when it comes to limiting the engine RPM. Trimpot VR2 only affects the RPM limiting response speed.

Step 6: press S2 to save the soft limiting settings.

Dimming adjustments

Pressing S1 again brings up the dimming adjustment mode (LED1 to LED3 all lit, LED 4 off).



This view shows how power MOSFETs Q4 and Q5 are bolted to the case and their tabs isolated using insulating washers and bushes. Voltage regulator REG1 mounts in a similar fashion – see also Fig.5. Note that diode D4's leads should be surrounded with neutral-cure silicone to prevent them from vibrating and breaking.

It's now just a matter of covering the LDR sufficiently (both front and back) to bring the LED brightness down to the minimum level you require and then pressing the Set switch (S2) to save the setting. The three LEDs will then flash five times to indicate that this has now been stored.

Note that the above procedure is best carried out in a room with a low ambient light level (but not dark).

That done, adjust VR3 to set the ambient light level threshold at which dimming begins (this may take some trial and error).

By the way, changing the 10μF capacitor at pin 12 of IC1 to 1μF will increase the rate at which the LEDs dim or become brighter in response to ambient light changes.

Installation

The unit is relatively straightforward to install, and requires only a limited amount of external wiring. This involves wiring for the +12V and ground (0V) connections, the rev signal input and the connections to the fuel injectors.

The +12V supply can be obtained from the fusebox and must be switched on (or off) by the ignition. Note, however, that this supply rail must remain on when the engine is being cranked (ie, when the starter motor is running). The 0V rail can be connected to the vehicle's chassis. These supply connections can be

Parts List – Shift Indicator and Rev Limiter for Cars

1 PC board, code 749 (Main), size, 101 × 81mm
1 PC board, code 750 (Display), size, 42 × 19mm
Available as a set from the *EPE PCB Service*
1 diecast case, 111 × 60 × 54mm
1 SPDT 30A horn relay
1 relay base to suit horn relay (optional)
3 2-way PC-mount screw terminals (5.08mm spacing)
1 PC-mount 0-F BCD DIL switch (S3)
2 SPST micro tactile switches (S1,S2)
2 16-way IDC PC-mount headers
2 16-way IDC line plugs
2 6.8mm PC-mount spade terminals
2 6.8mm insulated spade crimp connectors
3 rubber grommets for 6mm cable diameter
3 TO-220 silicone insulating washers
3 3mm insulating bushes
4 M3 × 10mm tapped nylon standoffs
8 M3 × 6mm screws
3 M3 × 10mm screws
3 M3 nuts
1 2-way header with 2.54mm spacing (LK1)
1 jumper plug (for LK1)
3 PC stakes
1 1m length of 16-way IDC cable
1 160mm length of 0.8mm tinned copper wire
1 1m length of figure-8 20A automotive wire
1 1m length of red medium-duty automotive wire
1 1m length of black medium-duty automotive wire

Semiconductors
1 PIC16F88-I/P microcontroller, pre-programmed – see text (IC1)
1 7805 +5V 3-terminal voltage regulator (REG1)
2 IRF9540 *P*-channel MOSFETs (Q4,Q5)
3 BC337 *NPN* transistors (Q1-Q3)
2 1N4004 rect. diodes (D1,D2)
1 UF4003 ultrafast diode (D3)
1 BY229 fast diode (D4)
2 1N4148 signal diodes (D5,D6)
2 16V 1W Zener diodes (ZD1,ZD2)
2 18V 1W Zener diodes (ZD3,ZD4)
1 5mm high-intensity green LED (LED1)
1 5mm high-intensity yellow LED (LED2)
2 5mm high-intensity red LEDs (LED3,LED4)

Capacitors
3 100µF 16V radial elect.
2 10µF 16V radial elect.
1 2.2µF 63V radial elect.
2 47nF MKT polyester
1 10nF MKT polyester

Resistors (0.25W 1% metal film)

1 100kΩ	2 1kΩ
1 30kΩ	5 220Ω
1 22kΩ 0.5W	2 100Ω
5 10kΩ	1 47Ω 1W
2 2.2kΩ	

Trimpots and LDR
2 1kΩ horizontal mount trimpots (VR1,VR2)
1 500kΩ horizontal mount trimpot (VR3)
1 LDR (50kΩ light and 10MΩ dark resistance) (LDR1)

run using medium-duty automotive hook-up wire.

The rev signal can be derived from the coil's negative terminal, and this wire connects to the HI input. Alternatively, in a multi-coil car, you can use the ECU tachometer signal, and this should go to the LO input.

Injector wiring

Fig.7(a) shows the basic set-up for standard injector wiring. Note that the engine management system (ECU) switches the negative side of the fuel injectors.

The first step is to disconnect the injectors from their existing common positive supply rail. After that, it depends on whether you are opting for hard limiting or soft limiting.

If you are opting for hard limiting, it's simply a matter of wiring in the relay as shown in Fig.7(b). This involves first connecting the vehicle's existing +12V injector supply rail to the relay's common (C) contact. The normally closed (NC) contact is then connected to the positive injector terminals.

Note that all wiring to the relay contacts and to the injectors should be run using 20A automotive cable.

Note also that, for hard limiting, no connections are made to points A and B on the circuit board.

Alternatively, if you are opting for soft limiting, then you need to wire the injectors as shown in Fig.7(c). In this case, **the vehicle's existing injector positive supply rail is connected to point A on the main PC board. Point B on the circuit board then becomes the new injector positive supply rail.**

The relay is also wired into the circuit as before. Once again, be sure to use 20A automotive cable for the wiring to the injectors, the relay contacts and to points A and B on the PC board.

Why use the relay with soft limiting?

Strictly speaking, if you elect to use soft rev limiting, the relay shown in Fig.7(c) is optional. However, we still recommend wiring it into the circuit for a couple of reasons.

First, by using the relay as shown, its NC contacts take the load off the soft limiting MOSFETs (Q4 and Q5) during normal engine operation. However, if the rev limit is reached, the relay quickly opens and the MOSFETs then take over to provide the soft limiting function – ie, they pulse-width modulate the new injector supply rail.

Second, the relay's contacts ensure that the injectors are still supplied with power during normal running if the MOSFETs become faulty or if a fault develops in the unit which switches them off. For this reason, we strongly recommend that you include the relay as shown in Fig.7(c) – it's a worthwhile safety and reliability feature.

Table 2: BCD switch settings and details for various engine types

BCD switch setting (S3)	Cylinders (4-stroke)	Cylinders (2-stroke)	Pulses per RPM	RPM counter	Frequency/ 1000 RPM	Shift light response @ 1000 RPM	Shift light response @ 2000 RPM
1	1	–	0.5	Between each pulse	8.33Hz	120ms	60ms
2	2	1	1	Between each pulse	16.66Hz	60ms	30ms
3	3	–	1.5	Between each pulse	25Hz	40ms	20ms
4	4	2	2	Between each pulse	33.33Hz	30ms	15ms
5	5	–	2.5	Between each pulse	41.66Hz	24ms	12ms
6	6	3	3	Between each fourth pulse	50Hz	20ms	10ms
8	8	4	4	Between each fourth pulse	66.66Hz	15ms	7.5ms
9	Asymmetric 3-cylinder	–	3 over 2 RPM	Between each fourth pulse	25Hz	80ms	40ms
A	10	5	5	Between each fourth pulse	83.33Hz	12ms	6ms
B	Asymmetric 2-cylinder	–	2 over 2 RPM	Between each fourth pulse	16.66Hz	120ms	60ms
C	12	6	6	Between each fourth pulse	100Hz	10ms	5ms

Note that this wiring is run to the main board by feeding it through the adjacent rubber grommet and terminating it with spade crimp connectors. These connectors are then plugged into the A and B terminals.

Make sure that the crimp connections are nice and tight to ensure reliability and be sure to plug each into its correct terminal. A proper ratchet-driving crimping tool is a necessity here.

It's vital that all wiring is installed in a professional manner to ensure reliability. That means using proper automotive connectors to terminate the wiring and securing the wiring with tape and cable ties.

Testing

Once the wiring is complete, set the BCD switch to the number that suits your engine – see Table 2.

That done, start the engine and rev it to check that the shift and limit LEDs light at their correct RPM values. If you haven't programmed the unit yet, the initial settings are 1000RPM for shift1, 2000RPM for shift2, 3000RPM for shift 3 and 4000RPM for the limit.

The hysteresis is 200RPM for shift1 and 500RPM for the other thresholds.

If the shift points are incorrect and you are using the HI input, try installing link LK1 to change the input filtering. Alternatively, if you are using the LO input, LK1 has no effect and no adjustments to the input filtering should be necessary.

If the LEDs do not light at all, check that the RPM input signal is correctly connected.

Peak hold injectors

Finally, note that the soft limiting option is ***not*** suitable for injectors that operate with a so-called peak hold drive. This is where an initial high current is used to close the injector, but then the current is reduced by rapidly switching the injector signal on and off (this keeps the injector open, but with reduced power to the injector solenoid).

Note, however, that you can use the hard limiting option, provided that the relay contacts can handle the peak currents that drive this type of injector.

How can you tell if you have a peak hold injector? It will typically have a solenoid coil resistance of less than 1Ω ('normal' injectors typically have a resistance of 4Ω to 5Ω). ***EPE***

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Determining the shift points

How do you determine the best shift points to program into the Shift Indicator and Rev Limiter? In most cases, it's just a matter of driving the car and noting down a sensible RPM value for each gear change. The values can then be programmed into the unit, after which it's simply a matter of monitoring the LEDs to pick the gear-change points.

Alternatively, as mentioned in the text, you could set the three LEDs to give a 'ready', 'set' and 'go' indication for each gear change.

The rev limit can simply be set to just under the tacho's redline value. Note, however, that many modern cars include rev limiting as part of their engine management system. In that case, you won't need the rev limiting feature provided by this unit, and it's just a matter of leaving out the wiring between this unit and the fuel injectors (you can also leave out the relay, power MOSFETs Q4 and Q5 and transistors Q1-Q3).

If you are modifying a car for racetrack use, then the shift points would be set much more aggressively – typically at those points that provide maximum acceleration. In some cases, you might want to set the shift points at close to engine redline. In other cases, it may be a matter of picking the maximum engine power points.

Recycle It!

BY JULIAN EDGAR

Using the convex lenses from fancy car headlights

Good quality convex lenses can be salvaged for next to nothing from car wrecking yards. Here's how to use them to make a really bright handheld spotlight or a broad-beam bike light.

WHEN you watch cars go by at night, you can see a variety of headlight designs on display. For example, old cars use sealed beams, which are often rather yellow in appearance. Then there are the whiter designs with replaceable halogen bulbs, while recent luxury cars feature high intensity discharge lights, which have a brilliant blue/white colour.

There are also lights that, when viewed at an angle, appear to have red or blue beams graduating to white as the car is seen face-on. These headlights have an abrupt beam cutoff and a very even spread of light within the beam. They are known as 'projector' headlights, and use a simple reflector teamed with a large convex glass lens.

A projector headlight is easily recognised because of its convex glass lens.

Want to know something? Those large glass lenses can be obtained for nearly nothing from broken headlights at car breaker's yards. Want to know something else? They make excellent lenses for use in bike lights, torches and handheld spotlights.

Projector headlights

A typical projector car headlight is shown in Fig.1. From the front, there's a cover plate of glass or plastic. Behind that is the convex glass lens (normally used only on low beam), followed by the bulb and then a simple reflector. The bulb is masked so that the upper part of the beam is abruptly cut off, to avoid blinding oncoming drivers

The single headlight assembly also contains a high beam, which usually comprises a conventional halogen lamp and a reflector. The headlight is near worthless to car breaker's if the cover glass is broken, the high beam is broken, the low beam is broken or the rear plastic housing is shattered.

However, if the low beam convex glass lens is intact, the convex lens can be bought for next to nothing. For example, at a major wrecking yard, I found and salvaged three convex lenses and took them to the front counter.

I made the point that I hadn't needed to break any headlights to obtain the lenses and asked for a price. The man behind the counter was puzzled: what on earth did I want these lenses for? I told the truth – I was making a bicycle headlight – and he charged me £6 for all three.

On another occasion, when I was buying some other car bits, the convex lens didn't cost me anything extra.

Many recent cars have projector headlights; but also some older cars,

Large convex glass lenses are easily salvaged from wrecked car headlights that use a 'projector' design. These lenses use high transmission glass and are optically accurate.

This photo shows the components needed for a bright, wide-angle light (from left and then clockwise): convex glass lens salvaged from a projector car headlight; shortened stainless steel drinking cup and bracket made from aluminium angle; and a 1W Luxeon LED and narrow angle collimator mounted on a salvaged aluminium block. Missing from this photo is a cut-down uPVC plumbing cap to hold the lens in place over the end of the cup.

for example the Mazda 626 and Ford Mondeo. Some Nissan model's also have them, including one car that has two such lenses each side.

If you are salvaging the lens from a headlight with a broken cover glass, be very careful. It is extremely easy to cut yourself on the shards of glass, especially if you slip while wielding a screwdriver.

Incidentally, smaller lenses of a similar shape can also be salvaged from old slide projectors.

Using the lens

So you have a bunch of high-quality, large, convex glass lenses that you've obtained for next to nothing. Now what? I could get all theoretical and talk about focal lengths, beam angles and point sources, but let's forget all that. The easiest way of coming up with the best design for your particular application is to simply play around with the light source and the different lenses.

For example, a Luxeon LED makes an excellent light source because it is small, very bright and has high efficacy. Power-up the LED (after mounting it on a suitable heatsink if it's a 3W or 5W design) and hold the convex lens in front of it.

Now view the beam pattern on a wall or the ceiling. By altering the distance between the lens and the LED, it's possible to change the beam from a broad diffuse beam to a narrow spot. In the case of the Luxeon, you can also try matching the glass lens with the various collimators available for these LEDs.

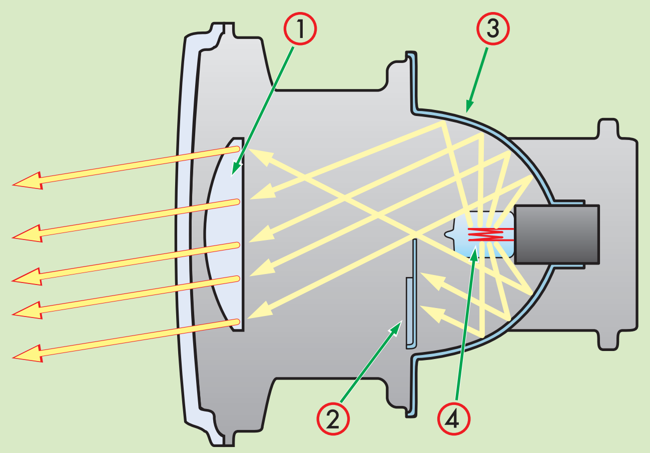


Fig.1: this diagram shows a 'projector' type car headlight. The main optical element is a large convex glass lens mounted within the headlight assembly (1) and this replaces the reflector and flat glass lens used on other headlights. A shield (2) prevents on-coming driver glare, while (3) is the rudimentary headlight reflector and (4) is the bulb. [Bosch]

The lenses can also be used with conventional incandescent bulbs and reflectors (and incidentally, lots of working torches with perfectly good reflectors are thrown away each day).

Again, it's a case of trying different combinations and looking at the results.

If the lens is placed very close to the light source, it's possible to get an extremely broad beam, which greatly

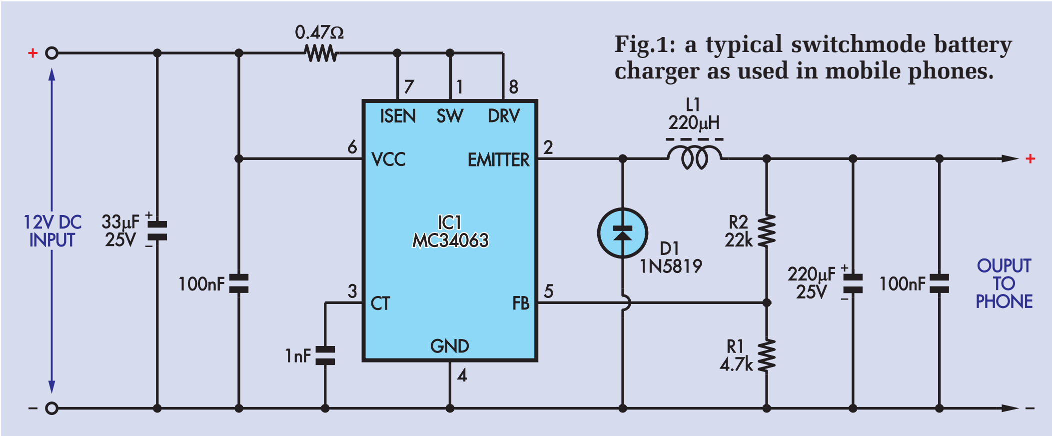


Fig.1: a typical switchmode battery charger as used in mobile phones.

Cheap 1W Luxeon LED driver

Step-down switchmode power supplies are often used in preference to their linear counterparts in applications where there is a large input to output voltage differential. Such is the case when driving Luxeon 1W Stars and their derivatives from a 12V DC source, which is the focus of this circuit.

Mobile phone chargers based on the MC34063 switchmode controller IC are easily modified to operate as a simple constant-current source, suitable for powering a single 1W white or blue LED, or two 1W red LEDs in series. Defunct mobile phone chargers are readily available at local markets and on **ebay.com** for a few pounds.

These units are quite easy to pull apart. First, unscrew the metal nipple from the end and remove the fuse, then prise off the metal collar that holds the two halves together. You can then easily separate the two halves and extract the circuit board.

The circuit shown in Fig.1 is typical of most chargers, with some including a few extra components for indicator LEDs. Resistors R1 and R2 set the regulated output voltage, which can be calculated using the formula V_{OUT} = 1.25(1 + R2/R1). This will result in a 7.1V output using the values shown.

Because the MC34063 strives to maintain a constant 1.25V across R1, we can replace R2 with our 1W LED (Fig.2) and select a much smaller value for R1 using the formula I = 1.25/R1. Using a value of 3.9Ω, about 320mA of regulated current will flow through the LED.

To modify the charger, start by removing R1 and R2. Note that the labelling of the resistors on the circuit board will probably be different; use your multimeter or follow the tracks on the board to identify the resistors of interest.

Replace R1 with a 3.9Ω 1W resistor and wire the Luxeon Star into the R2 position using medium gauge hook-up wire. Keep the wire length as short as possible and make sure that you've connected the anode (+) to the positive output and the cathode (-) to the junction of R1 and R2. Do not connect anything to the metal heatsink of the Star; this ***must*** be isolated from the power supply terminals.

If you'd like to test the unit before connecting your (expensive) LED, temporarily connect a 10Ω 5W resistor in its place. Apply 9V to 24V to the input and measure the voltage drop across the 10Ω resistor; it should remain constant at about 3.2V.

Note that not all chargers have an output filter capacitor installed. Typically, this is a 220µF 10V or 16V electrolytic unit. To save a few cents, the manufacturers sometimes leave this component out, relying on the mobile's battery to perform the filtering task.

If the 220µF capacitor is missing from your charger's PC board, it should be installed *before* the supply is used. Use a 25V rated part if you intend to power the unit from more than 16V. This allows for accidental disconnection of the LED with power applied, where the output voltage will rise close to the input voltage.

Finally, data on the MC34063 can be downloaded from **www.onsemi.com** and a useful development aid is to be found at **www.nomad.ee/micros/mc34063**

Dave Sime,
Hughes, ACT.

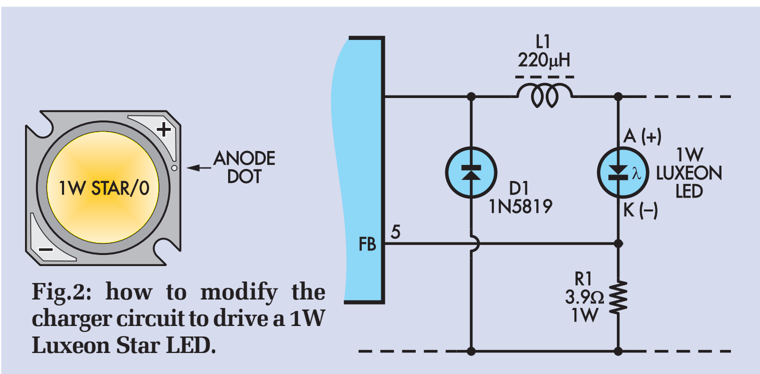


Fig.2: how to modify the charger circuit to drive a 1W Luxeon Star LED.

It's quite easy to modify a discarded mobile phone charger to drive a 1W Luxeon Star LED.

The Luxeon LED, its collimator and the mounting block are attached to the base of the cup using screws and nuts. The convex lens fits over the mouth of the cup to provide a broad, even beam.

Here the lens has been reversed compared to its normal automotive orientation, with the curved (convex) side facing the light source. This design is being used as a rear light on a road-going recumbent pedal trike.

enhances its visibility at night. It's just the shot for a flashing warning light or bicycle tail-light.

Building a compact light

I used a convex lens from a car headlight to make a very bright, broad beam, flashing tail-light for a bike.

First, a stainless steel drinking cup was shortened in length using a hacksaw and file. This gave a housing with an opening that matched the diameter of the lens. A 1W red Luxeon LED and a narrow-beam collimator were then installed on a small block of aluminium (a 1W Luxeon doesn't need a heatsink, but having one doesn't hurt), after which the block was mounted in the base of the cup.

Next, a uPVC plastic pipe cap to suit the diameter of the lens was obtained, and its inner diameter cut out with a holesaw. This gave a flange that fitted over the end of the cup, holding the lens in place. Silicone sealant was then used to secure the cap in place and to weatherproof the opening.

In this application, the best results were obtained by reversing the lens as compared to its normal car orientation – ie, it was mounted with the convex part of the lens facing the LED.

The Luxeon LED was powered by a 12V cigarette lighter phone charger adaptor, which was modified to act as a constant current source (see 'Cheap 1W Luxeon LED Driver' on the opposite page).

So why go to all this bother when LED tail-light flashers are cheaply available? Well, you've never seen a flasher like this. It is extremely bright from directly behind and can be seen at distances of 500 metres or more.

The convex lens creates a broader beam than would otherwise be achieved, allowing the light to be visible over a much wider angle than just having the LED on its own. This effect is further enhanced by reflections from the internal walls of the stainless steel cup. *EPE*

They're glass!

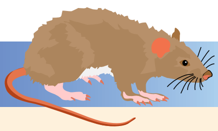
The convex lenses salvaged from car headlights are made from high quality optical glass. So if you drop them, hit them or squeeze them hard enough, they'll shatter!

Stainless steel cup

As detailed in the main text, a stainless steel drinking cup makes an excellent housing for the convex lens.

Single-wall stainless steel drinking cups can be hard to find, but a double-wall (ie, insulated) cup can be used instead, although it is heavier and a little more difficult to cut and drill.

Rat It Before You Chuck It!



Whenever you throw away an old TV (or VCR or washing machine or dishwasher or printer) do you always think that surely there must be some good salvageable components inside? Well, this column is for you! (And it's also for people without a lot of dough.) Each month we'll use bits and pieces sourced from discards, sometimes in mini-projects and other times as an ideas smorgasbord.

And you can contribute as well. If you have a use for specific parts which can easily be salvaged from goods commonly being thrown away, we'd love to hear from you. Perhaps you use the pressure switch from a washing machine to control a pump. Or maybe you have a use for the high-quality bearings from VCR heads. Or perhaps you've found how the guts of a cassette player can be easily turned into a metal detector. (Well, we made the last one up but you get the idea . . .)

So, if you have some practical ideas, do write in and tell us!

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TEACH-IN 2010

LADDER LOGIC PROGRAMMING FOR THE PIC MICRO

Part 5: Advanced Programming and Interfacing Techniques

By Walter Ditch

THE fifth and penultimate part of this series begins by exploring basic concepts related to hardware interfacing, including methods of connection to input devices such as switches, and to outputs including LEDs, 7-segment displays, relays, solenoids and motors. This knowledge will give you an appreciation of the hardware design of an actual industrial PLC – although, of course, the circuits considered will be rather more basic than those of a commercially available product. Hardware design is also important in embedded control applications, where the PIC becomes an integral part of an electronic system, adding intelligence and flexibility.

We'll also use the chosen examples to demonstrate the use of computer-based electronic simulation software, as illustrated by Proteus VSM from Labcenter Electronics. A number of tips and suggestions will be provided for those users wishing to combine PLC-style program development with use of electronic simulation software.

The article concludes by discussing a range of programming concepts, which have been grouped together under the umbrella term of 'advanced programming'. Topics covered include:

- Byte-oriented programming (data transfer, combinational logic, numeric comparison and arithmetic operations).
- Creation of simple state based systems by using the built-in sequencer feature.

Concepts covered here, and in previous parts of the series, will be pulled-together next month, with the final instalment focusing on the development of custom extensions to the software. A number of software solutions will be developed, making it straightforward to control the hardware devices discussed here, and many more besides.

Listings

As usual, all program listings for this series are available from the Library > Tutorials section of the *EPE* website (**www.epemag.com**). You'll also need the header files supplied with Part 1, which should be 'unzipped' into a single folder, together with the sample files from each part of the series.

Make sure you have installed the freely available MPLAB IDE software, which will be needed to assemble the example programs. And of course, in order to actually test the programs, you will need a suitable PIC development board, fitted with one of the supported PIC microcontroller types, or simulation software such as Proteus VSM from Labcenter Electronics.

Hardware design concepts

PIC microcontrollers are often used in 'embedded systems', where the PIC becomes a flexible and reprogrammable alternative to a hard-wired electronic circuit. Although sophisticated input/output circuitry is already provided in the commercial PLC, any interfacing hardware must be designed and built wherever a PIC microcontroller is deployed. Hardware design and software development are best thought of as two sides of the same coin, and must be considered together when any practical solution is being developed.

An appreciation of hardware interfacing techniques can also greatly add to the real world relevance of any ladder logic programs developed. It surely is more inspiring, for instance, to control a DC motor from a ladder logic output, rather than to simply turn an LED on and off – not least due to the many practical applications of motors.

Hardware interfacing concepts considered here will allow the PIC micro to be linked to a wide variety of hardware, including switches, LEDs, transistors, relays, motors, solenoids and optocouplers.

Starting with the data sheet

The definitive source of information for the hardware designer is the appropriate PIC data sheet, which may be downloaded from the Microchip website (**www.microchip.com**) in PDF (Portable Document Format) format, and then viewed using the freely available Adobe Reader software.

PIC devices really do vary, particularly in their current handling capacity, so make sure that you carefully read the data sheet for the actual microcontroller being used, prior to designing any interfacing circuitry.

Connecting input switches

PIC microcontrollers are based internally on CMOS technology, so any input circuits will draw negligible current, being effectively voltage controlled (input leakage currents of $1\mu A$ or less, are defined in the data sheet using the I_{IL} parameter). Acceptable voltage ranges for high and low logic levels are specified in the data sheet using the V_{IH} and V_{IL} parameters respectively, typically using a calculation based on the positive supply voltage V_{DD}.

This can seem complex, but assuming a 5V power supply and standard input circuitry, a logic 0 will be recognised as a voltage in the range 0V to 0.75V ($0.15 \times V_{DD}$), while a logic 1 will be any voltage in the range 2.05V to 5V ($0.25 \times V_{DD} + 0.8V$).

This makes it relatively straightforward to supply input data by using switches, using nothing more complex than a switch and a resistor for each port bit. This is illustrated by Fig.5.1.

(It is assumed here, and in following interfacing examples, that a simple ladder logic program is running, copying input port bits from Port A to the equivalent output port bits of Port B.)

Notice that the circuit shows three different switch interfacing methods, and several other circuit variations are possible. Switch SW1 provides a direct connection to logic 1 when closed, or a weak pull-down via resistor R1 when open. Switch SW2 and R2 provide the opposite polarity.

A further alternative is shown by switch SW3 and R3, where a weak pull-up or pull-down is applied. This latter circuit may be preferred for a general experimentation arrangement, particularly if there is any possibility of the port being configured as an output, since it avoids the possibility of an excessive output current.

Why use a 10k resistor? Well the precise value is not critical, but observe that the current flowing through the resistor of 0.5mA (or $500\mu A$) is considerably larger than the input port's leakage current of at most $1\mu A$, effectively overcoming any input port loading effects, and ensuring that input logic levels are correctly interpreted. The use of an appropriately sized pull-up/pull-down resistor also prevents the input port from acting as an antenna for stray electromagnetic interference, thus avoiding false triggering of input circuits.

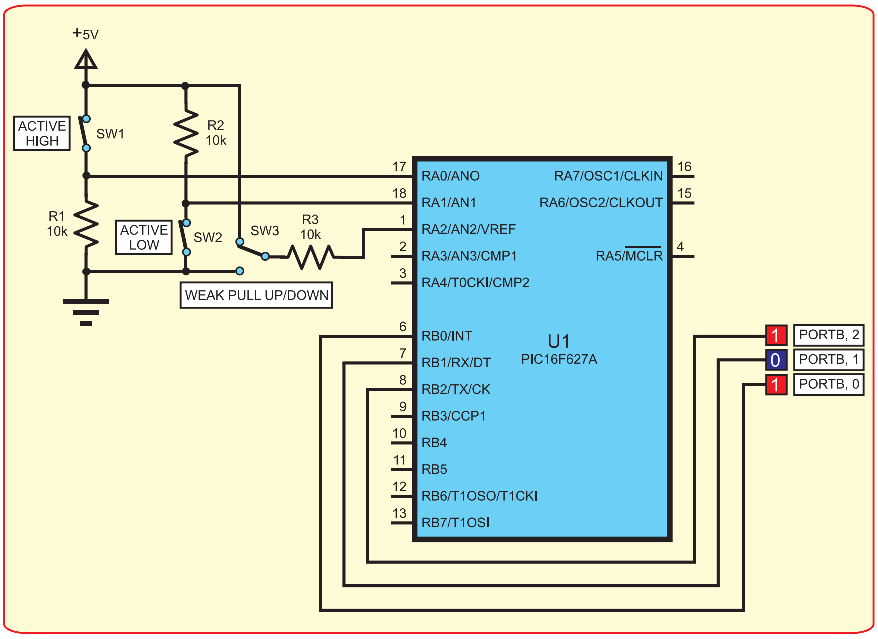


Fig.5.1. Methods of connecting input switches

Note: The supported PIC microcontrollers all have the capability to enable internal pull-up resistors connected to Port B. This option is disabled within the PLC software by default, but may be a customisation option in situations where Port B is configured as an input port (as in the PIC16F887 model).

While the circuit (Fig.5.1) is fine where input switches are directly linked to the PIC, it would not be adequate in cases where the user was allowed to make their own connections via input terminals. Higher voltages or incorrect polarities would be quite likely to occur, leading to the likelihood of damage to the microcontroller, or even the risk of electric shock to the user.

A more robust input circuit would be advisable in this case, incorporating some kind of electrical isolation of the low voltage and (potentially) high voltage sections. Optocoupler/optoisolator circuits are ideally suited to this purpose and these will be discussed shortly, following consideration of output devices.

Interfacing outputs

According to the PIC data sheet, the maximum current capacity of a single output port is 25mA, both at logic 1 (current being 'sourced' or flowing out of the pin), and at logic 0 (current flowing into the pin or being 'sunk').

However, there will also be an overall maximum current limit, either for the output port or for all output ports combined – and this is quite device specific. Some examples are listed below:

- PIC16F627A/628A/648A – maximum current sunk/sourced by PORTA and PORTB (combined) = 200mA.
- PIC16F87-88 – maximum current sunk/sourced by PORTA or PORTB (separately) = 100mA.
- PIC16F887 – maximum current sunk/sourced by all ports combined = 90mA.

Design constraints also exist related to the maximum current sunk or sourced, plus the overall power dissipated by the entire device. For example, the PIC16F627A/628A/648A data sheet gives the following values:

- Maximum current out of V_{SS} pin (negative power supply pin) = 300mA.
- Maximum current into V_{DD} pin (positive power supply pin) = 250mA.

- Total maximum power dissipation = 800mW (and the method of calculating this value is given in the data sheet).

A second consideration is the voltages involved, including both the supply voltage to the PIC itself, and also the actual worst case voltages likely to appear when a logic 1 or logic 0 is being outputted (stated as V_{OH} and V_{OL} respectively in the PIC data sheet). The minimum output voltage for a logic 1, V_{OH}, is defined as being $V_{DD} - 0.7V$, which for a 5V power supply, would be in the range 4.3V to 5V.

Similarly, the maximum output voltage for a logic 0, V_{OL}, is given as 0.6V, so a logic 0 output voltage will be in the range 0V to 0.6V. (These voltage levels are stated with output currents considerably less than the maximum of 25mA, so slightly worse figures may be found in practice.)

This gives us the necessary information to design output interface circuitry, noting that the PIC micro's powerful and symmetrical output drive circuitry provides us with great design flexibility (I_{max} = 25mA, both at logic 0 and also at logic 1).

Driving LEDs

First, let us consider the interfacing options for directly connected LEDs, as shown in Fig.5.2.

As can be seen, the symmetrical drive capability allows us to connect the LED either way round, with D1 being illuminated by a logic 0 output, and D2 by a logic 1.

A typical LED forward voltage of 2V and a maximum current of 10mA is assumed here, but forward voltages may vary depending on the colour of the LED, while the maximum current capacity will be related to the brightness of the LED and its power rating. Both voltage and current values should be obtained from the appropriate catalogue or data sheet and then used to calculate the value of the current-limiting resistor (R4 and R5).

The preferred value of 270Ω shown here will give a current of approximately 10mA, assuming that a voltage of 2.7V appears across the resistor terminals – or slightly less in the event of worst case output voltages of V_{OH} and V_{OL}.

Controlling larger currents and higher voltages

Where higher voltages and/or higher currents must be controlled, then a transistor output circuit is a good choice. Transistors come in many forms, including bipolar and field effect types, and high gain Darlington-pair composite devices are also available. To keep things simple, a circuit based on an *NPN* bipolar transistor will be considered here, as shown in Fig.5.3.

The *NPN* bipolar transistor is a three-terminal device, which is used here as a current controlled switch, with a relatively small current flowing into the base terminal (B) controlling a larger current flowing into the collector terminal (C). Essentially, either current is allowed to flow into the base terminal and the transistor turns on (and hence the lamp lights), or no current flows into the base, and the lamp and transistor are both off.

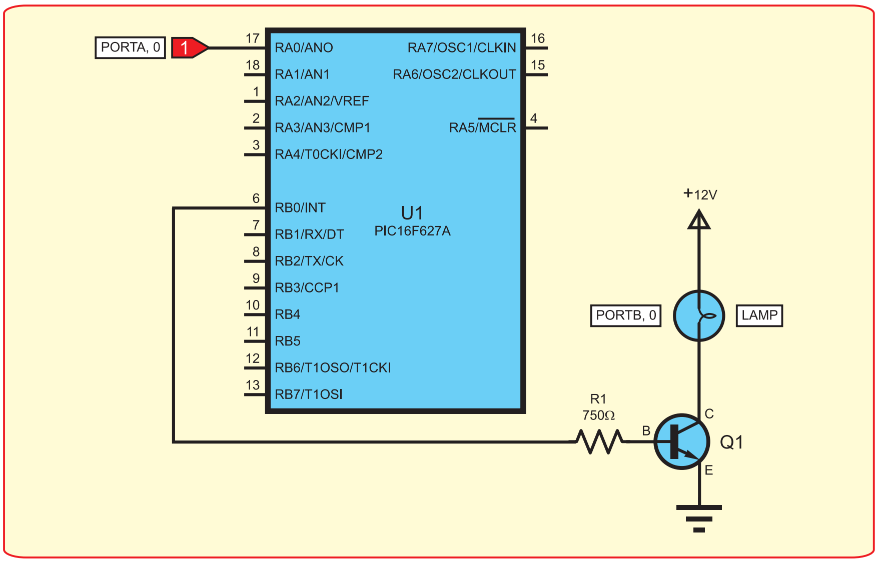


Fig.5.3. Controlling a 12V lamp by using a transistor switching circuit

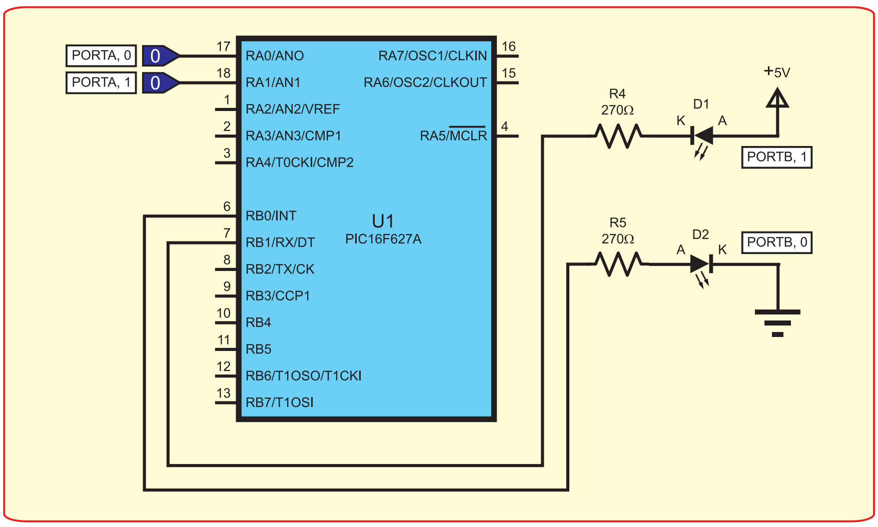


Fig.5.2. LED interfacing options

The transistor is enabled in the circuit of Fig.5.3 by outputting a logic 1 to bit 0 of Port B (pin 6), which in turn supplies a current of approximately 5mA to the base terminal of the transistor, via current limiting resistor R1. This small current is multiplied by the current gain of the transistor (referred to as h_{FE} or β in data sheets and equal to I_C/I_B) to become a much larger collector current.

When the transistor is switched on, almost all of the 12V supply appears across the lamp terminals, with only 0.1V to 0.2V across the collector-emitter (E) junction of the transistor (so V_{CE} = 0.1V to 0.2V, at which point the transistor is said to be 'saturated').

Strange as it may seem, this circuit is best designed by working

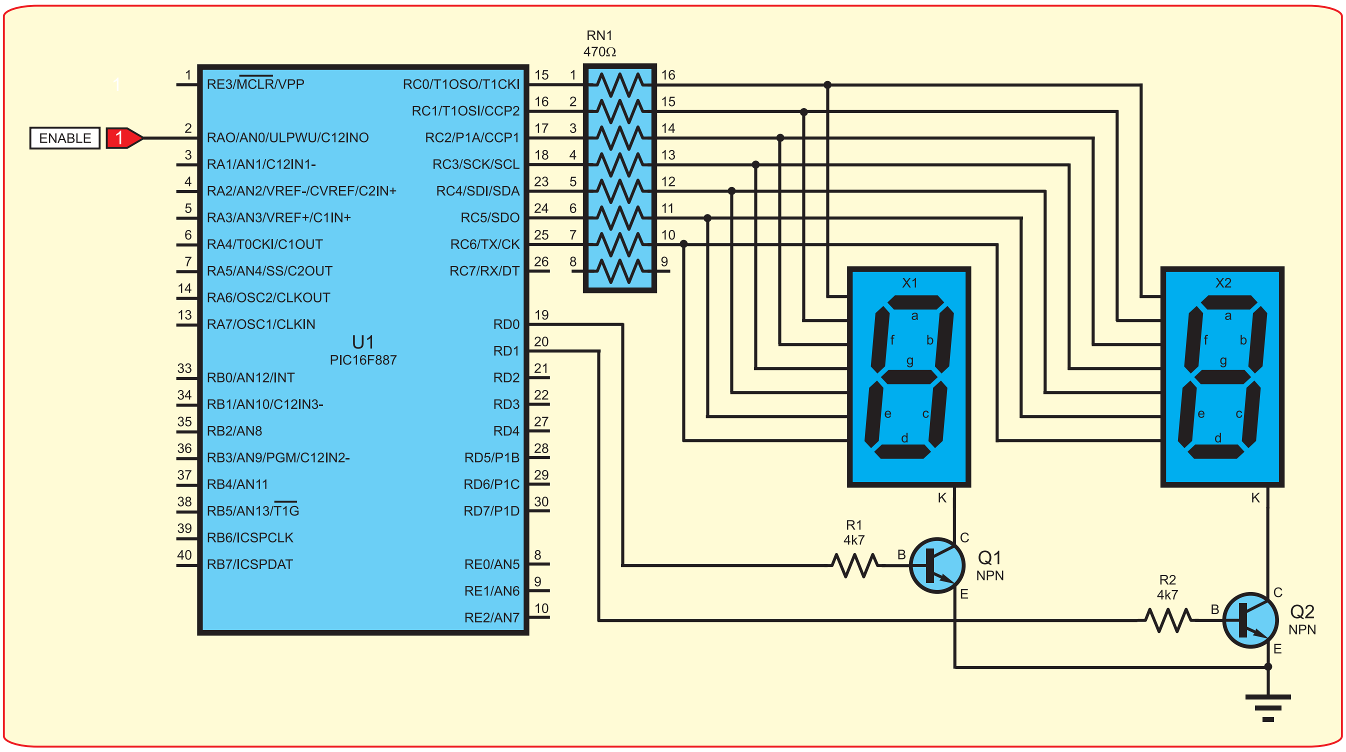


Fig.5.4. A simple multiplexed LED display

back from the output to the input, beginning with the lamp. To take an example, assuming the lamp is rated at 12V and has a resistance of 24Ω. A simple calculation shows that the lamp current will be 0.5A, so our first design conclusion is that we will need a transistor with a $V_{CE(man)}$ rating greater than 12V and I_C in excess of 0.5A, which is quite straightforward.

Next, the minimum h_{FE} is identified from the transistor data sheet and this is used to calculate the required base current ($I_{B(max)} = I_C/h_{FE(min)}$). So for example, if $h_{FE(min)} = 100$ and I_C = 500mA, then the required base current will be 5mA. (Recall that we need to keep this base current under 25mA in order to comply with the PIC's maximum current rating, so a value of 5mA flowing out of Port B bit 0 will be fine.)

The base-emitter junction of a conducting transistor is effectively a silicon diode, so a voltage of approximately 0.7V appears across the base-emitter terminals when the transistor is switched on. Given that the required base current is 5mA, a simple calculation provides us with the value of the current-limiting base resistor:

$$R_1 = V_{R1}/I_B$$

$$= (V_{OH} - V_{BE})/I_B$$

≈ 750Ω (the nearest preferred value in the E24 / 5% resistor series)

Further transistor switching applications

The previous transistor switching circuit is clearly useful in its own right, allowing larger current devices to be controlled, and also devices which have higher operating voltages. Equally importantly, it may be easily adapted to control devices such as 7-segment displays, or inductive loads such as relays, solenoids or even motors. As a first example, Fig.5.4 shows a pair of transistors used to alternately enable the digits of a multiplexed 7-segment common cathode display.

Each of the individual segments within the 7-segment display is a separate LED with its positive anode (A) connected via a current-limiting resistor to an output port bit. The negative cathodes (K) are internally linked and brought out to a terminal at the lower end of the 7-segment display (hence this is referred to as a 'common cathode' 7-segment display).

In a single digit display, the cathode connection may be simply grounded, but in a multiple-digit display (as shown in Fig.5.4), each display is enabled in a rapidly repeating sequence, giving the illusion that all digits are simultaneously illuminated. This 'time division multiplexed' arrangement is used in order to minimise the number of output ports bits required by multiple-digit displays. (Calculation of the value of the current-limiting resistors is similar to that already seen for a single light emitting diode, but the brightness is normally increased, since each digit is only illuminated for a fraction of the time.)

We will revisit this application next month, when custom macros will be developed to drive single- and multiple-digit 7-segment displays.

Inductive loads

A transistor may also be used to energise the coil of a relay, as illustrated by Fig.5.5.

In this example, the relay is shown energising a 24V lamp, but a more flexible arrangement would be to bring out the relay contacts to external screw terminals, allowing users to make their own connections, as appropriate. The addition of a normally reverse biased diode across the relay coil enables the energy stored in the magnetic field of the coil to harmlessly dissipate when it is de-energised, 'quenching' the momentary high voltage spike which would otherwise occur.

The same basic circuit may be used to energise other types of inductive load, such as a DC motors, stepper motors, or even solenoids – with electronic door locks and pneumatic

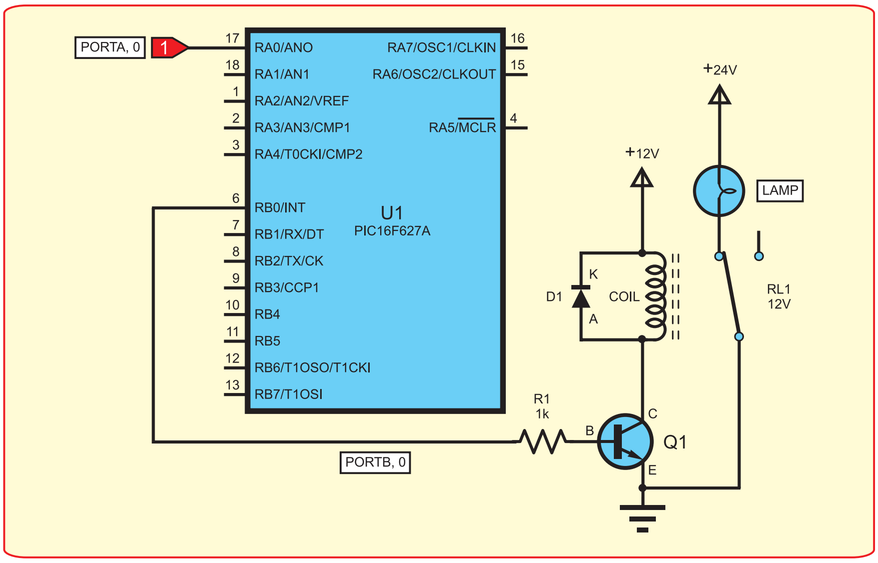


Fig.5.5. Controlling a relay using a transistor switching circuit

valves being just two applications of solenoids.

Although not considered here, it is also possible to use transistor circuits to provide bidirectional control of motors, or to energise the coils of a bipolar stepper motor with positive or negative polarity. Such a circuit would use two output port bits per controlled device, linked to a 'H-bridge' transistor circuit, with a small DC motor requiring one bridge (two port bits per motor) and a two coil stepper motor being linked to four output port bits.

Custom software routines to control stepper motors will be developed next month, in addition to the 7-segment displays already discussed.

Isolating high and low voltages

The relay output circuit considered previously has the advantage of providing a degree of electrical isolation between the low voltage control circuit, and the potentially higher voltages connected to the switch contacts of the relay. This same safety principle may also be applied to input circuitry, but this time based on optocoupler technology, as illustrated by Fig.5.6.

In this example, a 24V DC input is connected via a switch and current-limiting resistor (SW1 and R1 respectively) to the LED inside the optocoupler. Closing the switch causes the optocoupler LED to light, thus enabling the photo-transistor connected to the output.

The transistor within the optocoupler is wired as an emitter follower, which causes the emitter to be pulled up to almost 5V each time the internal LED is illuminated. This also illuminates the external indicator LED1 via current-limiting resistor R2, at the same time supplying a logic 1 input to the PIC microcontroller at pin 17 (RA0).

This type of input circuitry has two advantages. First, it allows connection of higher input voltages, and second it provides electrical isolation of potentially dangerous input voltages from the relatively expensive processor circuitry.

Bear in mind that the input protection circuitry of an actual PLC is likely to be more complex than that shown here, offering over-voltage and reverse polarity protection.

Proteus VSM simulation tips

Observant readers may have noticed that the circuits of Figs.5.1 to 5.6 are based on screenshots produced by Proteus VSM software from Labcenter Electronics. (The annotations for the transistors, diodes and relay coil have been added.) This neatly demonstrates the feasibility of mixed hardware and software simulation.

If you have access to this powerful software application, then the following simulation and debugging tips may prove useful:

1. For simple application and viewing of logic levels, the 'logicstate' and 'logicprobe' components allow logic 0/logic 1 inputs to be applied and displayed respectively. A momentary action 'logictoggle' input device is also available, and logic probes are found in two different sizes.

2. The default oscillator frequency of 1MHz should be changed to 4MHz on each inserted microcontroller, thus ensuring that time-critical programs operate at the desired speed.

3. Proteus VSM provides a variety of 'animated' components, which may be used to give a visual indication of circuit operation during simulation. Animated devices include switches, LEDs, 7-segment displays, lamps, relays, DC motors and stepper motors.

4. The 'virtual instruments' feature emulates common measuring instruments such as the ammeter, voltmeter, signal generator and oscilloscope.

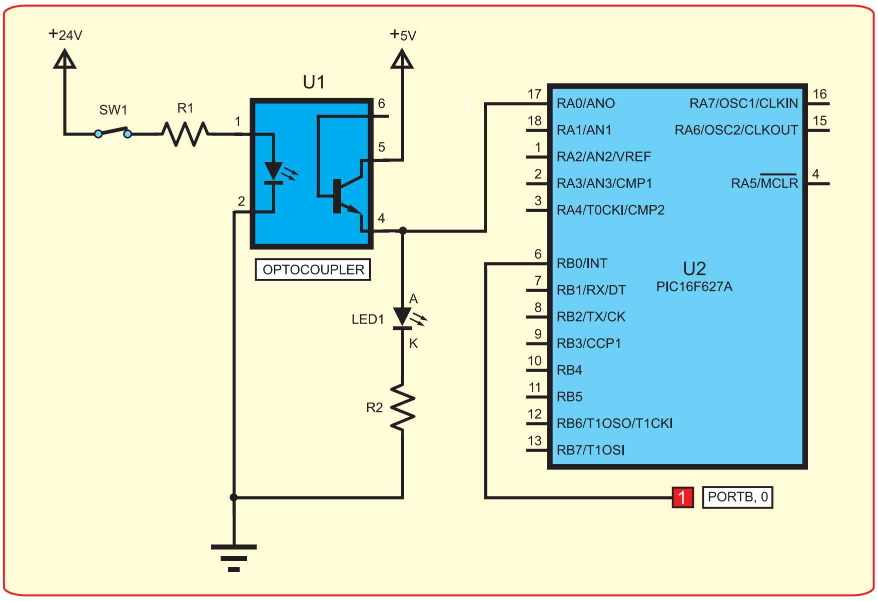


Fig.5.6. Providing input isolation by using an optocoupler

(Refer back to Part 2 Fig.2.2 to see the 'digital oscilloscope' in action.)

You also have the ability to pause the simulation and click on components in order to view instantaneous parameters, including voltage, current and power dissipation – which can often be simpler than placement of numerous measuring instruments. Dedicated microelectronics instruments are also available, including a multiple channel pattern generator and a logic analyser.

5. Proteus provides a built-in source code editor, plus a number of built-in assemblers, including MPASMWIN. Use of this assembler is an alternative to the MPLAB IDE, which has been used throughout this series. (Note that the MPASM assembler also supplied with Proteus does not recognise PIC16F887 source code files at the time of writing, although the MPASMWIN version seems to have no such problem.)

6. A variety of software debugging features are provided through a powerful integrated development environment (IDE). The 'watch window' is particularly useful for debugging ladder logic programs, allowing the content of selected internal registers to be viewed during run time. (Refer back to Part 3, Fig.3.3 to see this feature used when debugging a low-speed timer application.) Other IDE features include single step, breakpoints, source code view, plus register and memory view windows.

In general, I have found simulation of animated electronic devices to be trouble free, with a couple of minor exceptions. First, the connection of animated DC motors and stepper motors can give 'timestep too small' errors in mixed simulations. If you encounter this error, then one workaround might be to replace the motor with an animated lamp of the same rating, in order to demonstrate circuit operation.

Second, you may observe transient oscillation of outputs such as relay contacts in more complex simulations. This seems to relate to the method used by the PIC microcontroller to update an output port, in which the output port is first read (ie inputted), then updated and finally re-outputted. You can avoid this unwanted feedback effect by temporarily placing 'buffer' components between appropriate output ports and any external circuitry.

At this stage, you should now have a good appreciation of the hardware found in a typical PLC, and you should be able to design simple low voltage PIC interface circuitry for use in embedded control applications. The next section looks at the byte processing capabilities of the PLC software, which will be used to build a digital comparator, and also an adder/subtracter circuit.

Working with bits and bytes

Ladder logic excels at the manipulation of individual bits – for example reading inputs, performing simple combinational logic operations, and outputting the results. Certain other commands already considered may be regarded as either bit-oriented or byte-oriented, depending on the application.

This includes counters, timers and shift registers, all of which make use of a byte-sized 'working register', which may be optionally used by the programmer. Recall that commands have also been introduced which can load a byte-sized value into a register, or copy a byte from one register to another (the 'puti' and 'putr' commands respectively, first introduced in Part 3).

Use of byte-oriented commands can greatly simplify the writing of certain programs, and a further advantage is their efficient coding and high speed of execution. The only potential downside, for those new to microelectronics at least, is the greater conceptual difficulty when working with byte values, compared with individual bits. This may include the need to work with a variety of numbering systems, such as binary, octal, hexadecimal and decimal, in addition to the representation of signed and unsigned numeric values (2's complement arithmetic for example.)

The PLC software's dedicated byte processing capabilities fall into the following categories:

- Byte data transfer – using the 'puti' and 'putr' commands, as discussed above. (Please refer back to Part 3, Table 3.1, Listing 3.6, and associated text for more details.)
- Byte logical commands – performing combinational logic operations on each bit of a register simultaneously.
- Byte comparison – comparing byte values using operators such as 'less than', 'equal to', 'not equal to', 'greater than', and their combinations.
- Byte arithmetic – adding and subtracting byte values (with subtraction using 2's complement arithmetic).

Byte logical commands

Byte logical commands perform combinational logic operations such as AND, OR, and XOR on each bit of a source register, combining the source with a 'mask' to produce a result byte. Careful choice of logical operation and mask byte allows a variety of operations to be performed, including setting, clearing, inverting or copying selected bits.

Each command offers a matched pair of operations, which is selected by the value of the mask bit:

- AND with 1 to copy the source bit unaltered. AND with 0 to clear the output bit to zero
- OR with 1 to set the output bit to 1. OR with 0 to copy the source bit unaltered
- XOR with 1 to invert the source bit. XOR with 0 to copy the source bit unaltered.

These possibilities are illustrated graphically by the example of Fig. 5.7, in which a binary source byte '1010 1010' at the centre of the figure is combined with a mask byte of '1111 0000' to produce three different result bytes by using AND, OR and XOR operations at the left, right and bottom respectively.

The PLC software offers two different versions of each command, as shown in Table 5.1.

As usual, command names are supplied in lower case and register names are upper case. Notice that command names ending with 'r' (register)

Logical Operation	*Syntax and Addressing Mode*	
	(Register, Immediate) -> Register	*(Register, Register) -> Register*
AND	andi SRC_REG, BYTE, DST_REG	andr SRC_REG1, SRC_REG2, DST_REG
OR	ori SRC_REG, BYTE, DST_REG	orr SRC_REG1, SRC_REG2, DST_REG
XOR	xori SRC_REG, BYTE, DST_REG	xorr SRC_REG1, SRC_REG2, DST_REG

Table 5.1. Byte-oriented logic commands

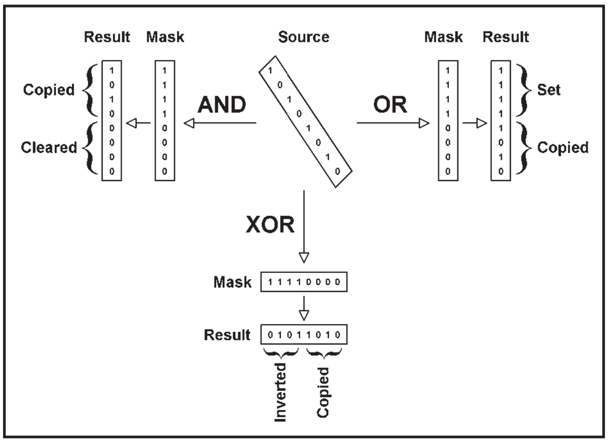


Fig.5.7. Bit masking with byte logical commands

combine a pair of registers, while an 'i' (immediate) combines an immediate value with a register. In each case, the result is written to a specified destination register.

A practical application will be given in the next section when bit masking and byte comparison commands are combined to make a digital comparator.

Byte comparison commands

As their title suggests, byte comparison commands perform numerical comparisons between two values, producing a logic 1 value if the comparison is true. In fact, you may recall that we briefly discussed byte comparison commands in Part 3, making use of the 'eqi' (equal immediate) command to test an immediate value and a register, as part of the light chaser program of Listing 3.9.

The full range of byte comparison commands and options are given in Table 5.2.

As an example, we will design a digital comparator which will compare two 4-bit numbers, referred to as 'A' and 'B', producing three outputs, 'A > B' , 'A < B' and 'A = B'. A possible program is given in Listing 5.1, written for the PIC16F887 microcontroller.

The program is relatively straightforward, beginning by masking off the upper 4 bits of Ports A and B, storing the results in auxiliary registers AUX0 and AUX1. These intermediate values are then compared, with the three possible comparator results being written in order to bits 0–2 of Port D.

Byte arithmetic instructions

The PLC software provides the ability to perform addition and subtraction of byte values, with available command options shown in Table 5.3.

This is likely to be one of the lesser used features, and also one of the more conceptually difficult, due to its use of 2's complement arithmetic. However, potential applications might include control-oriented systems in which a measured parameter such as temperature, pressure, or speed of rotation is compared with a set point, with a subtraction command producing a deviation value. This feature might, for example, form part of a PID (proportional, integral, derivative) controller.

The example of Listing 5.2 performs addition and subtraction of two 4-bit numbers, outputting the results to two 8-bit registers.

Unfortunately, a full discussion of 2's complement arithmetic is beyond the scope of this series, but note that the program of Listing 5.2 will display any negative subtraction results in 2's complement form on Port D. The following information may be useful when interpreting displayed results:

- In an 8-bit representation, positive 2's complement numbers are allowed to be in the decimal range 0 to +127, and negative decimal numbers are between -1 and -128. The most significant bit of the subtracted result indicates the sign, with zero indicating a positive result and one showing a negative 2's complement value.

- Positive binary numbers are converted to 2's complement 'negative' form by first inverting each bit, and then adding 1 to the

```
include "16F887.PLC"              ; Defines PLC instructions

andi    PORTA, b'00001111', AUX0  ; Mask upper 4 bits of Port A,
                                  ; placing result in AUX0 (number 'A')
andi    PORTB, b'00001111', AUX1  ; Mask upper 4 bits of Port B,
                                  ; placing result in AUX1 (number 'B')

eqr     AUX0, AUX1                ; Test if A = B
out     PORTD, 0                  ; outputting result to bit 0 of Port D

gtr     AUX0, AUX1                ; Test if A > B
out     PORTD, 1                  ; outputting result to bit 1 of Port D

ltr     AUX0, AUX1                ; Test if A < B
out     PORTD, 2                  ; outputting result to bit 2 of Port D

endp                              ; Marks end of PLC program
```

Listing 5.1. A 4-bit comparator program (Lst5_1.asm)

Arithmetic Operation	Syntax and Addressing Mode	
	(Register, Immediate) -> Register	(Register, Register) -> Register
Add	addi SRC_REG, BYTE, DST_REG	addr SRC_REG1, SRC_REG2, DST_REG
Subtract	subi SRC_REG, BYTE, DST_REG	subr SRC_REG1, SRC_REG2, DST_REG

Table 5.3. Byte arithmetic commands

Compare Operation	Syntax and Addressing Mode	
	(Register, Immediate) -> Register	(Register, Register) -> Register
Less than	lti SRC_REG, BYTE, DST_REG	ltr SRC_REG1, SRC_REG2, DST_REG
Less than or equal	ltei SRC_REG, BYTE, DST_REG	lter SRC_REG1, SRC_REG2, DST_REG
Equal	eqi SRC_REG, BYTE, DST_REG	eqr SRC_REG1, SRC_REG2, DST_REG
Not equal	nei SRC_REG, BYTE, DST_REG	ner SRC_REG1, SRC_REG2, DST_REG
Greater than	gti SRC_REG, BYTE, DST_REG	gtr SRC_REG1, SRC_REG2, DST_REG
Greater than or equal	gtei SRC_REG, BYTE, DST_REG	gter SRC_REG1, SRC_REG2, DST_REG

Table 5.2. Byte comparison commands

```
include "16F887.PLC"              ; Defines PLC instructions

andi    PORTA, b'00001111', AUX0  ; Mask upper 4 bits of Port A,
                                  ; placing result in AUX0 (number 'A')
andi    PORTB, b'00001111', AUX1  ; Mask upper 4 bits of Port B,
                                  ; placing result in AUX1 (number 'B')

addr    AUX0, AUX1, PORTC         ; Send result A + B to Port C
subr    AUX0, AUX1, PORTD         ; Send result A - B to Port D

endp                              ; Marks end of PLC program
```

Listing 5.2. Addition and subtraction of two 4-bit numbers (Lst5_2.asm)

```
include "16F627.PLC"         ; Defines PLC instructions and sequencer data
                             ; held in EEPROM - see org H'2100' section

ld      PORTA, 0             ; Enable input - single-shot sequence

seq     d'27', OSCL, 0       ; Sequencer with 27 steps (0-26)
                             ; 8 Hz clock input (T = 131.1 ms)

putr    SEQ, PORTB           ; Copy sequencer value to Port B

endp                         ; Marks end of PLC program
```

Listing 5.3. Producing a single-shot sequence with default data (Lst5_3.asm)

```
include "16F627.PLC"         ; Defines PLC instructions and sequencer data
                             ; held in EEPROM - see org H'2100' section

ld_not  SEQFIN, 0            ; Enable input - continuously running

seq     d'27', OSCL, 0       ; Sequencer with 27 steps (0-26)
                             ; 8 Hz clock input (T = 131.1 ms)

putr    SEQ, PORTB           ; Copy sequencer value to Port B

endp                         ; Marks end of PLC program
```

Listing 5.4. Producing a repeating display (Lst5_4.asm)

```
                                  ; ** This section initialises EEPROM data

org     H'2100'                   ; Put EEPROM data here for use by the
                                  ; seq (sequencer) command
                                  ; Up to 256 bytes are available with the
                                  ; PIC16F88.
                                  ; Traffic light data is shown below:

de      B'00000100'               ; Step 0 - Red
de      B'00000110'               ; Step 1 - Red + Amber
de      B'00000001'               ; Step 2 - Green (1 of 5)
de      B'00000001'               ; Step 3 - Green (2 of 5)
de      B'00000001'               ; Step 4 - Green (3 of 5)
de      B'00000001'               ; Step 5 - Green (4 of 5)
de      B'00000001'               ; Step 6 - Green (5 of 5)
de      B'00000010'               ; Step 7 - Amber
```

Listing 5.5. Custom traffic light sequencer data

```
include "16F88_L.PLC"        ; Defines PLC instructions and sequencer data
                             ; held in EEPROM - see 'ORG 2100H' section

ld_not  SEQFIN, 0            ; Enable continuous operation
and     PORTA, 0             ; with a separate enable input

seq     d'8', OSCL, 3        ; Sequencer with 8 steps (0-7)
                             ; 1 Hz clock input

putr    SEQ, PORTB           ; Copy sequencer value to Port B

endp                         ; Marks end of PLC program
```

Listing 5.6. The traffic light program (V1.01_Files/Lst5_6.asm)

result. The inverse process of subtracting 1 and then inverting each bit converts a negative number back to positive form.

The next and final section introduces the sequencer feature, which extends the concept of byte processing to incorporate simple state-based systems.

Sequencer-based systems

The built-in sequencer facility makes it easy to create complex animated sequences, with user-defined data in EEPROM memory being sent at regular intervals to the chosen destination register. Single-shot or repeating sequences may be produced with up to 255 steps, depending on the capacity of the EEPROM memory within the chosen microcontroller. Typical applications of the sequencer include toys, festive decorations, shop signs, running-light displays, and many more besides.

(Note that the 16F627A and 16F628A microcontrollers have 128 bytes of built-in EEPROM, while the 16F648, 16F88 and 16F887 offer 256 bytes. Please refer back to Part 1, Table 1.1 for a detailed list of microcontroller features.)

Writing sequencer-based programs is a little different to that seen so far, since the user's program is effectively merged with sequencer data contained within the PLC header-file during assembly. The first step is normally to create a separate folder to hold both the custom header file and the source code file for the sequencer project. Next, the header file is edited so that it contains the required sequencer data. Finally, a suitable ladder logic program is written and assembled in the normal way.

For the sake of simplicity, sample sequencer data

for a running light display has already been placed into the header files supplied with Part 1 of the series. The only remaining step is to write a short sequencer program, with a simple example shown in Listing 5.3.

This program produces a non repeating output sequence on Port B, which is triggered by an active-high enable input connected to bit 0 of Port A. This enable input must be held continuously high during the sequence, causing the sequencer to be reset when it goes low.

The sequencer itself is defined using the 'seq' command, which in this case has 27 steps in the sequence (to match the data defined in the header file supplied with Part 1 of the series). Output data from the current step in the sequence is held in the SEQ register, which is displayed on output port B by the 'putr' command.

It is quite simple to adapt this program in order to create a continuously running sequence, as shown in Listing 5.4. In this case, the 'sequencer finished' status bit, 'SEQFIN, 0' is first inverted and then used as the enable input to the sequencer. At first, the sequencer is enabled (because it is not yet finished), but the status bit becomes set on completion. This resets the sequencer, causing the sequencer to restart.

The sequencer feature is best suited to applications not requiring any great decision making capacity, where a fixed output sequence is to be generated at regular intervals. If a more flexible system is required then a 'finite state machine' may be a better choice, and this type of system will be explored as a customisation topic in the final part of the series.

Creating a custom sequence

Having mastered the sequencer programming side of things, the next step is to create our own custom sequencer data. A simple traffic light display will be used as an example to illustrate the process involved.

If you have not already done so, you should download the file containing zipped program listings for Part 5 of the series; as usual, extracting these to the same folder used for other parts. You should notice that a sub-folder called 'V1.0.1_Files' has been created. This folder contains an updated set of header files, which have been modified to include the traffic light sequencer data, with the relevant sequencer content for the PIC16F88 microcontroller being shown in Listing 5.5.

Notice that EEPROM data is specified as a series of data bytes, starting at hexadecimal memory location 2100. The actual sequencer data consists of eight steps, with the red, amber and green traffic lights assumed to be connected to the rightmost sequencer output bits.

Assuming that each step lasts for one second, then we can see that the green output will be active for five seconds, with all other states lasting one second each. The sequencer will operate in continuous mode, automatically returning to state 0 after the final state, thus giving an amber to red transition.

A suitable traffic light program is given in Listing 5.6, this time written for the PIC16F88 with low voltage programming enabled.

Notice that continuous operation has been enabled, and an additional enable input has been added, linked to bit 0 of Port A. (The updated software supplied in Version 1.0.1 turns-off the sequencer output when it is disabled, and makes other minor corrections, as detailed in the release notes.)

Readers with Proteus VSM simulation software may optionally connect a 'traffic lights' component to the output port, as shown in Fig.5.8. For others, the program may easily be adapted to run on supported hardware platforms, in which case the colour of the traffic light LEDs may need to be imagined!

An interesting exercise for the reader would be to extend the above system to control a pair of traffic lights at a crossroads (north-south and east-west operation). You may also like to think of other applications of sequencers, including electronic toys and decorations. Development of new systems and applications can be both interesting and creative, and will also give you plenty of opportunities to practise your hardware design skills.

Summary

We have covered a lot of ground this month, ranging from hardware design and the use of computer-based simulation, to byte-oriented programming, and even simple sequencer-based systems. Several of these topics will be expanded in the next and final part of the series, which will focus on customisation of the software.

Next Month

In the final part of the series we will add a number of custom extensions to the PLC software, creating an updated version in the process. This will greatly extend the range of potential applications of the software. Topics considered will include:

- Configuring device options (port directions, watchdog timer, option and configuration register settings).
- Conditional subroutines – executing a block of code if a condition is true.
- Using lookup tables for code conversion – converting binary codes to and from other formats (a technique with a surprisingly large range of potential applications).
- Finite state machine – creation of powerful and flexible state-based systems.

These extensions will enable us to control devices, including 7-segment displays, DC motors and stepper motors, with the possibility of digital position measurement using Gray code.

We will also revisit the traffic light application one last time, demonstrating that a finite state machine approach offers increased flexibility compared to the sequencer-based method considered above.

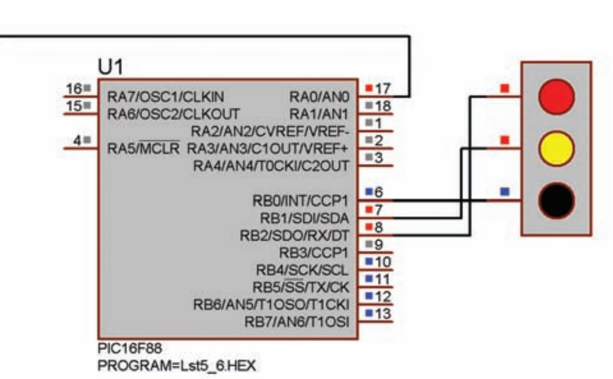


Fig.5.8. Connecting a traffic light component in Proteus VSM

Why Do They Do That?

IN *Circuit Surgery* we usually try to answer 'how do I do that?' type questions, but this month, it is more of a case of 'why do *they* do that?' Where 'they' are the designers of the ICs we use, and the 'why' relates to the use of low supply voltages for modern electronics.

The choice of this topic was prompted by the following question posted by ***Thomas Scarborough*** on the *EPE Chat Zone* (**chatzones.co.uk**).

My experience of electronics tells me that it is awkward to try to run anything off less than about three volts: CMOS, discrete, and so on. However, take a digital recorder/player I recently bought: 1.2 volts. Among other things, it has an orange LED! How do these things ever work?

A number of replies on the forum suggested the use of voltage step-up ICs, with ***epithumia*** citing the MAX1947 as an example. This is how LEDs and other parts of systems which have to have higher voltages to operate are powered when the battery voltage is below their working voltage. However, it is not the whole story. Many readers will be aware that the supply voltage (core voltage) of microprocessors, such as Intel's Core-2 chips, is typically in the range of about 0.85V to 1.4V. So, it is evident that digital circuits can work at these low voltages. In fact, they *have* to run at these low voltages, something we will return to shortly.

Stepping-up

If a step-up chip is used, then at least one part of the system must work at the lower voltage to run the step-up process. The approach taken by the MAX1947 is quite interesting in this respect. The datasheet (see **maxim-ic.com**) reveals that it uses a 'bootstrap' approach. It contains a start-up oscillator, which can run on the minimum specified input voltage for the device, which is about 0.7 to 0.8V.

This oscillator runs a switching conversion which brings the output voltage to around 1.6V. Once this output level is achieved, it is used to power the reminder of the IC's internal circuitry – the main DC-to-DC converter, which boosts the output voltage to the required value.

It is common for modern portable personal electronic gadgets, such as the music player Thomas mentions, to run off low-voltage battery supplies. This is convenient because a single small battery can be used, but often requires other voltages to be generated. LEDs require higher voltages because the physics of their operation determines the 'forward voltage' required for them to emit light. For an orange LED this is typically about 2.2V, for blue and white LEDs it is higher, usually at least 3.3V.

Many digital ICs require low voltages, often in the 1V to 3.3V range, because higher voltages would destroy the transistors used in their circuits, and because lower power consumption (and hence battery life) is a critical requirement in such gadgets – using lower supply voltages helps achieve lower power consumption. The fact that different parts of such products might require different voltages is reflected in the vast number of DC-to-DC conversion and power management ICs aimed at designers in this market.

In perspective

The perspective stated by Thomas, 'that it is difficult to get anything to work below 3V' is one based on designing with discrete components, using traditional circuit techniques. A bipolar transistor requires about 0.7V to switch on, so a 1.2V supply does not give you much headroom. However, the IC designers working on modern digital chips will be using circuits based on MOSFET transistors (CMOS) with threshold voltages typically below 0.5V, maybe around 0.3V or even lower.

The basic circuit structure of logic gates remains the same at these low supply voltages, but analogue circuit designs may be radically different. Many new approaches to low-voltage analogue design have been published over the last twenty years, but often these designs are based on silicon (not discrete components) and some approaches employ special device structures, such as multi-input floating gate MOSFETs.

It is developments in digital, rather than analogue circuits, which have caused the move to low supply voltages. Digital circuitry dominates modern products such as MP3 music players and mobile phones, and analogue design has adapted to its requirements. The low power supply voltages we have today are a direct consequence of the dramatic increase in performance of electronic products over the last few decades. This exponential growth in electronic functionality was predicted by Gordon Moore in 1965; known as Moore's law, it states that the number of transistors on an integrated circuit would double approximately every 18 months to two years.

For example, Intel's first 8-bit processor, the 8008, was produced in 1972 and contained 3,500 transistors. The recent Intel Core i7 64-bit processor, launched in 2009, has about 780 million transistors. We need between 17 and 18 'doublings' to produce this two-hundred-thousand-fold increase over 37 years (18.5 two-year periods), so this is in line with Moore's Law.

Moore's Law has held for over forty years, although it may not continue much longer due to the fact that transistors are becoming so small that atomic and quantum effects may prevent much further progress. However, other 'fundamental' limits have been predicted before and passed.

Scaling theory

Behind the empirical data of Moore's Law lies *scaling theory*, this is what has driven the improvement in circuit performance. The basic idea behind scaling is that by making transistors smaller you get faster circuits, which take up less space on the silicon, or of course you can put more functions on a chip the same size.

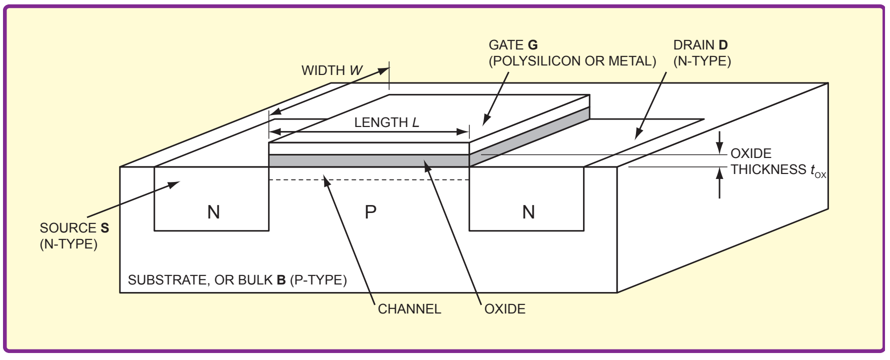


Fig.1. Structure of an NMOS transistor

Doing this is not trivial, because you have to develop new fabrication technology which is capable of reliably manufacturing large quantities of chips using the smaller transistors. However, scaling theory does allow you to predict how the next generation of technology will behave and what you can achieve with it.

Scaling theory was first developed by Robert Dennard and his colleagues at IBM in 1972 and published in a paper in 1974 in the IEEE *Journal of Solid-State Circuits*. Dennard is also notable as the inventor of Dynamic Read Only Memory (DRAM) in 1967 (patented in 1968).

Fig.1 shows a simplified schematic of an NMOS transistor, showing key physical dimensions: the channel length, L, the channel width W, and the gate oxide thickness, t_{ox}. In scaling a technology, these physical dimensions are reduced by multiplying by a factor k. So the minimum transistor channel length changes from L_{min} to kL_{min}, and similarly the oxide thickness is reduced to kt_{ox}. Other transistor parameters are scaled in the same way.

The usual value for k is 0.7 (ideally $1/\sqrt{2}$), that is physical sizes are scaled down by 30% to go to the next generation of circuits. Capacitance in transistors is proportional to their area divided by the oxide thickness, WL/t_{ox} (capacitance increases if you increase the size of the plates or bring them closer together). This means capacitance scales by (0.7×0.7)/0.7 which is 0.7. Circuit delays scale down by 0.7, which means clock frequency can increase by a factor of 1.43 (ie 1/0.7).

The area of a chip is proportional to the area of all the transistors, each of which has area W×L, which scales by 0.7×0.7, which is about 0.5. So the circuitry takes up half the space on the new generation technology; or to put it another way, you can have double the number of transistors on a chip and hence twice the functionality running 43% faster.

IC technology generations are described in terms of a characteristic size relating to the manufacturing process, which is based on the smallest feature size possible in that generation. Initially, this was measured in micrometres (μm), but now it is in nanometres (nm). These values are often referred to as *technology nodes*.

Until 2005, this was usually taken as being the half-pitch of metal interconnections on DRAM; which was representative for all types of IC. More recently, as IC technology and scaling has got more complex, this single representative node idea is less meaningful.

Readers interested in the details of IC technology development should consult *The International Technology Roadmap for Semiconductors* (ITRS). This is a regularly published assessment of the next fifteen years of the semiconductor industry's future technology requirements, and contains a large amount of technical data. Their website is at **itrs.net**.

Powerful issue

An interesting issue with scaling is what to do with the power supply voltage. Ideally, it should be scaled by k like everything else, but that may be inconvenient. If each new generation of chips uses different supply voltages, then their logic levels will not be compatible between generations, possibly making system design and interfacing difficult. Not scaling the voltage down also means that potentially the clock frequency can be increased by more than 1.43 times because CMOS delay decreases at higher supply voltages.

During the 1980s, supply voltages were not scaled and new chip generations kept the same supply voltage at 5V. The consequence of this so called *constant voltage scaling* is that the electrical field strengths (volts per meter) inside the chips increase. Scaling in which the supply voltage is reduced proportionately is called *constant field scaling* because the electric field strengths in the chip remain constant.

The increasing field strengths in constant voltage scaling cause problems such as hot carrier injection (HCI), in which charge carriers (electrons) are accelerated so much that they are able to penetrate parts of the chip where they should not be, causing damage to the chip and degrading performance. High field strength in the gate oxide causes time-dependent dielectric breakdown (TDDB) and hence transistor failures.

Another consequence of constant voltage scaling, is excessive power dissipation and chip heating. Switching power consumption in CMOS circuits is proportional to V^2fC where V is the supply voltage, f is the (clock) frequency and C is the load capacitance being driven (which in the simplest analysis is proportional to the transistor gate capacitance).

For constant voltage scaling, this power remains constant, or increases by ($1/k$) depending on the scaling of the clock frequency. This means that the power dissipation per unit area of the chip (power density) increases significantly ($1/k^2$ to $1/k^3$). Use of constant field scaling reduces power dissipation problems because switching power is reduced by k^2, the same factor as transistor area, so power density remains constant from one generation to the next.

No longer viable

The problems with constant voltage scaling meant that this approach did not remain viable after the 1980s (0.8μm technology node) and hence the 1990s saw a reduction in power supply voltages, particularly for advanced logic ICs such as microprocessors. This is illustrated in Fig.2, which shows supply voltage (V_{DD}) and MOSFET threshold voltage (VTH) against technology node.

The scaling theory we just described is somewhat simplified in a number of ways. In practice, voltages and transistor dimensions are not scaled by the same factor as they should be in pure constant field scaling. Also, it is not possible to scale everything by factor k; for example, MOSFET threshold voltages is one area in which scaling is difficult. It can be seen in Fig.2 that the threshold voltage has not scaled down at the same pace as supply voltage.

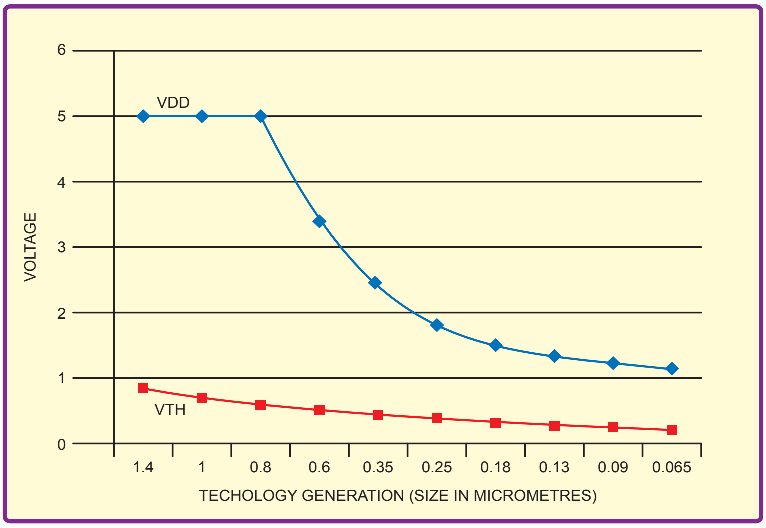


Fig.2. Changes in supply voltage (V_{DD}) and MOSFET threshold voltage (VTH) with IC technology generation. The change from constant voltage scaling (5V supplies) to constant field scaling at the 0.8µm node is clearly seen

Low threshold voltage is a problem because the transistors do not turn off very well, resulting in leakage currents. Although the leakage of each transistor is small, when it is multiplied millions of times it represents a significant power demand and is a serious problem in the most recent IC generations. Another complicating factor in scaling is that developments in circuit design techniques change the characteristics of circuits (such as maximum operating frequencies) and again cause deviations for idealised scaling theory.

A consequence of the fact that 'perfect' constant field scaling has not been possible is that power density and power dissipation did not remain constant as technology developed in the 1990s. This means that chips such as microprocessors have continued to produce more and more heat. Anyone familiar with PC motherboards as they progressed from using early 386s, via various Pentiums, to the latest models will have been aware of the increasing importance of the heatsink and cooling fan for the processor.

Back in the late 1990s, if you had plotted the trend for the power density of an Intel processor, and projected it forward to now you would have predicted processor power densities approaching that of the surface of the Sun (which is around 6000 W/cm^2).

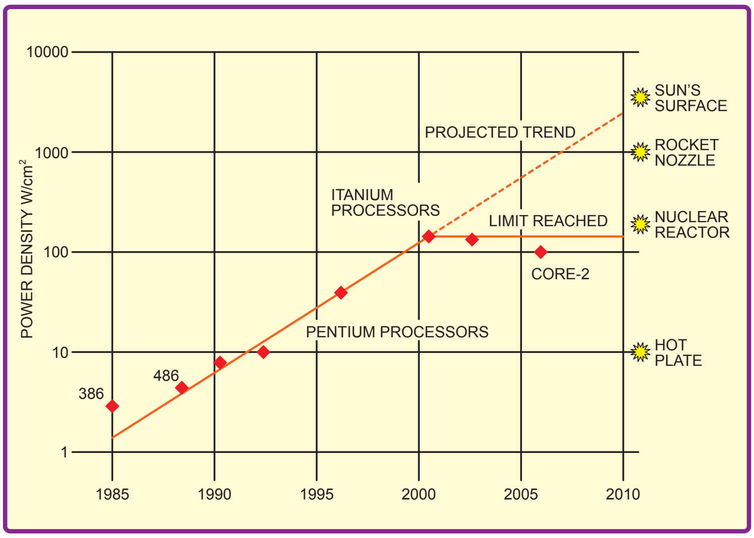


Fig.3. Intel Processor power dissipation. This graph is usually attributed to Shekhar Borkar of Intel

This is illustrated in Fig.3, which along with the Sun's surface, has a hot plate, a nuclear reactor and a rocket nozzle as power density reference points.

This figure is widely reproduced (in various forms) in technical papers, articles and presentations. It is often attributed to Shekhar Borkar, now director of Intel's Microprocessor Technology Lab. Borkar did as we just described, and analysed the trends, at that time, in processor development, publishing a paper in the IEEE's *Micro* magazine in 1999. This was a very real problem for Intel – they cancelled the 4GHz Pentium 4 in 2001 due to heat dissipation problems. Subsequently, they announced dual core processors.

Like the move away from constant voltage scaling to lower supply voltages, this was another breakpoint where continuing to scale in the same way as before was not going to work. Forced water cooling could probably handle processors dissipating up to around several hundred W/cm^2, but this would not be economically viable for everyday office and home PCs. Thus, power dissipation for processors has levelled off and increased performance has been achieved by improvements in processor architecture – moving to multiple core designs.

In this article, we have just scratched the surface of a large and complex subject. However, we hope we have shown the reason that modern digital (and mixed analogue and digital) ICs often use very low power supply voltages and why supply voltages have been changing over the last couple of decades.

References

R. H. Dennard *et al*, 'Design of ion-implanted MOSFETs with very small physical dimensions,' IEEE *Journal of Solid-State Circuits*, SC-9, pp.256–268, 1974.

Borkar, S. 'Design challenges of technology scaling,' *Micro*, IEEE , vol.19, no.4, pp.23-29, Jul-Aug 1999

Haron, N.Z. Hamdioui, S. 'Why is CMOS scaling coming to an END?.' *3rd International Design and Test Workshop*, IDT 2008. pp.98-103, 20-22 Dec. 2008

The International Technology Roadmap for Semiconductors. **www.itrs.net**

PIC n' Mix

Mike Hibbett

Our periodic column for PIC programming enlightenment

Easing Software Development

When writing software for a new project, particularly when using a new microcontroller in a new circuit, it's essential to start with a working and reliable framework. Creating this *each time* you build a new circuit becomes very time consuming, and you will find yourself repeating old mistakes, which gets very frustrating. Wouldn't it be better to design a simple framework once, and then reuse it?

We've covered this idea before in assembly language but it's worth taking a look at how we can address the issue when programming in 'C', a language we are told is 'portable'.

In the frame

Having a flexible, reusable debugging and development framework that can be easily reused does require that the language you have written it in is itself portable between different processors. Assembly language is one of the least portable languages around, and even porting between a PIC16 and a PIC18 processor will prove a challenge.

Worse, if you design it with the 'lowest common denominator' in mind, then you will need to make compromises that reduce the utility of the software, making it hardly worth the effort. 'C' does indeed improve on this, but does itself suffer from portability issues. The difference is, however, that in 'C' the non-portable aspects can be isolated into a small portion of the code, with the rest being easily transferable between processor types – so long as you take a little care up front.

Fans of the 'C' programming language will tell you how portable a language it is, and that is true, up to a point. However, most PIC processors have a highly unusual 'non-standard' processor architecture, which does not fit well with the 'C' language. 'C' was designed for processors with a common code and data address bus, and a stack that exists within the normal address space.

The lower-end PIC processors have a separate code and data address space, and a very limited hardware stack. 'C' compilers that target these processors have to be somewhat imaginative in their application, and rely on some 'extensions' to the language to work.

The higher-end processors, such as the PIC32, have a completely different architecture to the PIC18 or PIC16 families (the PIC32 is, in fact, not a Microchip core at all, but a MIPS) and so do not suffer from this problem. As most of us will use C on a PIC18 or PIC24, we will have to take the differences into account.

Framework

As with any other project it's important to define what you want to achieve before sitting down and writing code. Here is our list:

- Easy to modify for new projects
- Provide a template for source file layout
- Provide a stable hardware configuration
- Utilise low power operation
- Provide a serial interface for debugging
- Easy-to-enhance debugging facilities.

The first point is obvious, but the second may be less so. When you write software, especially a lot of it, the code can be much more readable if you use a consistent style. Comment headers for files and individual functions help you understand what the program does when you come back to it after a long break (or decide to reuse old code in a new project.)

The debugging features are not essential, but will prove very useful, if you have a spare UART interface available. If your application will require the only UART present on the chip, then it is still worth keeping a debugging interface during initial development until your code is stable. You should, as a minimum, try to keep a single I/O pin free for debugging output – even turning a pin high or low can help solve problems.

Once you have a serial port available for debugging it's possible to add very powerful software 'tools' into your framework to inspect variables and read or write to flash memory. Every application has its own particular features that benefit from inspection during development, so having an easy-to-expand debugging system should be on our wish list.

Stable setup

The most important feature of any framework is to provide a known, stable setup. Even with a trivial hardware design, there is nothing more frustrating than spending hours de-soldering and resoldering a circuit, trying to locate a hardware fault, only to find it's a software error. Just ask any hardware engineer.

Investing the time in getting a reliable system early on means that you can relax and concentrate on the fun stuff, progressing easily through the design. The initial implementation of a framework requires you to have a clear understanding of the inner workings of your hardware and microprocessor – or more specifically, the nuances of its datasheet – and getting this done first will mean no surprise circuit changes later on. Having an existing framework that you can 'port' to your new design will speed this process up too, and help you get to the fun stuff more quickly.

Practical example

Although a standard framework may provide more features than you need or have code space for, these features can be removed as your own design progresses.

So let's not spend any more time talking about it, and take a look at a practical example.

We've put together a framework based around the PIC18F45K20. It's a fairly standard PIC18F processor, chosen simply because it's the part fitted to the PicKit3 Demo Board, and so it is easy to experiment with. (We'll be reviewing the PicKit3 in a later issue.)

The software is available on the *EPE* website, in this month's archive. The file is called *PicNMix-C-framework.zip*. We have

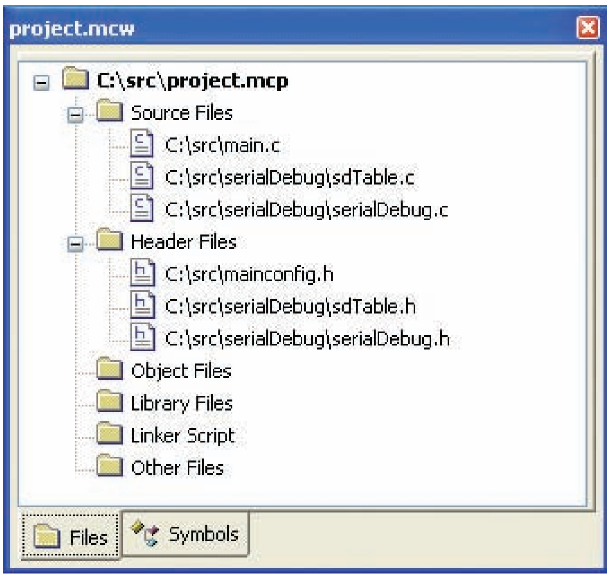


Fig.1. Source code layout

used the Microchip MPLAB integrated development environment and C18 C compiler as these are free and very powerful. Ironically, porting this code to a different vendor's compiler could be more difficult than porting it to another Microchip processor because different vendors handle the PIC's C language extensions in different ways.

Organisation

The source code organisation can be seen in Fig.1. Including the Microchip **.mcw** and **.mcp** project files, only eight small files are required for implementation. Your own source code is placed in **main.c**, and you can add further project files as you see fit. The serial debugging support code has been isolated in its own subdirectory as it is completely independent of your project code.

Your main program source code is placed in the file main.c, located in the top level directory with the two MPLAB project files. You are free to add additional source files and link them into main.c; this file simply adds the hardware initialisation and debugging support. **mainconfig.h** adds a single location in which to store the configuration bit settings for your chosen processor.

The main() function within main.c is a simple loop, typical of main embedded application control loops. There are two calls of interest here: Sleep() and serialDebug().

The sleep call is optional, and is used to place the processor into a lower power state. The call effectively halts program execution until an interrupt has taken place. It's only of use if you wish to run the processor at low power.

The serialDebug call is the 'hook' into the debugging support system. It normally executes just two simple 'if' statements and then returns, so consumes very little of your processing time. Only if a command has been entered via the serial port does it activate and run whatever command you have entered. It then outputs whatever message your debug handling routine provides, and then goes back to 'quiet mode'.

Debug command

The SerialDebug function is implemented in the file **serialDebug.c**. The only other function in this file, **sdRxChar()**, is the routine called by the main application whenever a character has been received for the debugger. You would call this from whatever method you use for receiving serial data from the outside world. The main.c file provides an example interrupt driver receive function, which calls sdRxChar, but you can replace it with your own code if you wish – even a bit-bashed serial receive interface.

A debug command can have parameters expressed in decimal or hexadecimal, and enable you to implement complex commands, such as display regions of flash or ram memory. The way the commands are processed by SerialDebug is shown in Fig. 2.

```
    /* See if we can find the command requested */

    cmdLen = strlen(rxBuff);

    if ( (rxBuff[0] == '\r') || (rxBuff[0] == '\n') ) {

        /* Looks like just the enter pressed. Show prompt */
        putrsUSART((const far rom char *)"\r\n> ");
    } else {

        /* Has a valid command name been entered? */
        while (
                (sdp->name != NULL) &&
                (strncmpram2pgm((far rom char *)sdp->name, rxBuff, cmdLen) )
              ) {

            sdp++;
        }

        /* If we have, call the handler, otherwise display error msg */
        if ( sdp->name != NULL ) {
            putrsUSART((const far rom char *)"\r\n");
            sdp->funcptr(ptr);
            putrsUSART((const far rom char *)"\r\n> ");
        } else {
            putrsUSART((const far rom char *)"\r\nInvalid command. Try 'help'\r\n> ");
        }
    }

    /* Allow the debugger to receive further commands */
    cmdReceived = 0;
}
```

Fig.2. Debug command selection

The highlighted line of code in Fig. 2 does all the work. A data structure variable cmdTable (pointed to by sdp) is defined in **sdTable.c**. This variable is a table listing the commands available with the function names and a short textual description.

Using a table like this significantly simplifies adding new functions into a debugging system. Once your new feature is implemented, you simply add a single line to the cmdTable variable and your function will become available and visible in the list of commands.

Smaller processors

And what about the PIC16, and smaller families? C compilers do exist, but the challenge is greater. Smaller processors are less complex and so can be mastered quickly anyway, making a portable development framework less important. There may be less code and data space available for a debug system too. In cases such as these, you have to rely on a simulator to debug the code, and perhaps an LED being controlled by debug statements at interesting points.

Coming up

Next month, we step away from the Microchip range of processors for a change and take a look at a very unusual one – the humorously named 'Propeller' processor from Parallax Inc, the people who brought us the Basic Stamp. This processor has on-chip video generation support hardware, and promises colour video generation. It looks like it could be very interesting!

Practically Speaking

Robert Penfold looks at the Techniques of Actually Doing it!

When I first started building electronic projects, which was probably long before most *EPE* readers were born, electronic kits were all the rage. In the kit's accompanying instruction leaflet you were frequently encouraged to handle all the components to familiarise yourself with them, and to ensure that you could accurately identify each one.

This might still sound like a good idea, and it certainly has some merit, but it is not advice that you are likely to be given these days. In fact, you are likely to be warned against any unnecessary handling of some components.

Hands-free

I suppose that this change in approach has been brought about by two changes in electronics. One is simply that the components used to be relatively large and tough. Some of the older valves (tubes) had glass cases that would almost certainly break if they were dropped on the floor, but most components were large by current standards, and pretty robust. Most modern components are primarily designed for automated construction methods, and in normal use they receive little or no handling.

This is not to say that they will fall apart in your hands. However, the 'look but don't touch' approach has some merit with modern components, and when you do need to handle them it is usually best to adopt the 'kid gloves' approach. In particular, it is not a good idea to start bending and forming leadout wires until it is actually time to fit the components into place. The way in which the leadout wires are connected to the body of the component seems to be a weakness with some modern components.

Pulling the leads can cause problems, but the more usual source of trouble is when bending a leadout wire close to the body of the component, and it is something that should be avoided as far as possible. There seem to be a variety of reasons for this action causing damage, which is often in the form of a leadout wire breaking off completely. In less severe cases, it seems to be a weakness in the body of the component that results in part of it close to the lead breaking away.

Glass-cased diodes are perhaps the most common source of this problem, but it can occur with resistors and other axial components (the tubular type that have a lead at each end). The damage does not necessarily prevent the component from working and staying within its specification. However, a component that shows obvious signs of physical damage is unlikely to have good reliability, and it is advisable to discard it and obtain a replacement. There should be nothing to worry about if the damage is simply damage to the paint.

A drawback of some small resistors is that the manufacturing process seems to make the leads quite weak where they enter the body of the component. This has to be regarded as a design flaw, and if you obtain any resistors of this type it is probably best to avoid buying any more. Again, the problem comes to a head if the leadout wire is bent close to the body of the component. The wire bends at the weak point, and if you are unlucky it breaks off.

There is often no way of telling whether a component is one of the more vulnerable types or one that is relatively tough, so it is probably best to handle and use all of them with due care. Avoid any unnecessary flexing or bending of the leadout wires, and when forming leadout wires, avoid any bends very close to the bodies of the components. A strategically place fingernail or screwdriver blade makes it easy to produce a bend at the required point in a lead, while not placing undue force on the nearby sections of the lead.

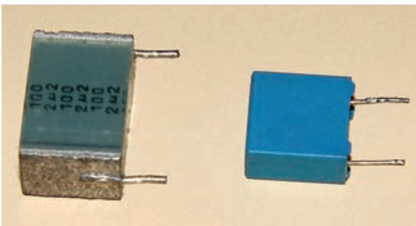


Fig.1. Open construction capacitors like the one on the left are far less hardy than the cased type on the right. Any capacitors that lack a proper casing should be treated very carefully

End of a capacitor

Some printed circuit mounting (PCM) capacitors used to be notorious for the ease with which one of the leads would part company from the rest of the component. Any outward pressure on the leads was likely to result in one of the leads splitting away from the body to which it was soldered. With this type of capacitor it was not just a matter of avoiding unnecessary handling. When fitting a component of this type it was important to make sure that it dropped easily into place and, where necessary, to carefully straighten the leads in order to make the component a proper fit prior to fitting it onto the circuit board. Simply squeezing a component into place if it was a poor fit was likely to result in one of the leads coming adrift.

Modern PCM capacitors are mostly much tougher than the early types, which often lacked a proper casing to give overall strength to the component. An old PCM capacitor is shown in Fig.1 (left), and its open construction is readily apparent. Fig.1 (right) shows a modern equivalent, which has a fairly tough plastic case that protects the component and holds the leads firmly in place.

There are still open-style PCM capacitors in circulation, and they must be treated with due care if you use them. It is also worth bearing in mind that some PCM capacitors that appear to have a plastic case actually have something that could more realistically be regarded as a thick coating of paint. This type of coating is good at keeping out moisture and other forms of contamination, but does not really impart a great deal of strength to the component. Capacitors such as these need to be treated with due care, and are not much tougher than the open construction type.

It is really non-electrolytic PCM capacitors that tend to suffer from the problem of dropping leads. PCM electrolytic capacitors use a different form of construction that makes them physically quite tough. The problem is mainly associated with the larger non-electrolytic components that have some form of plastic dielectric, which mainly means the polycarbonate, polyester, and Mylar types.

These days it is perhaps the physically tiny capacitors that tend to be the most vulnerable. Some types, such as ceramic and tantalum capacitors, seem to be designed with small physical size as the priority, and physical strength as an afterthought. In addition to problems with detached leads, some ceramic capacitors are quite thin and brittle. Pieces can break off if they are not handled and used carefully.

Charged atmosphere

A major difference between the components of today and those of (say) 50 years ago, is that the components of yesteryear were not vulnerable to high voltages. They were mostly designed to operate with potentials of a few hundred volts, or even a few thousand! By comparison, modern components seem to be predominantly designed for use on supply potentials of just a few volts. Voltages even slightly higher than this can prove to be fatal for many modern integrated circuits.

This vulnerability to quite modest voltages becomes a serious problem when it is combined with the various MOS technologies that are used in the manufacture of many modern semiconductors. The components are reasonably safe once fitted

into a completed circuit board, but there is a real risk of them being zapped before they actually reach the circuit!

The source of the problem is the voltages present in a normal environment, some of which are surprisingly high. Most of the time you are left unaware of their presence and these voltages only become apparent when they reach sufficient magnitude to grab your attention. This usually means something like your hair standing on end, or a spark being generated each time you stroke the cat.

Semiconductors that are not manufactured using MOS technology tend to be regarded as safe from static charges, while MOS devices are regarded as highly vulnerable. There is some truth in this belief, but it is probably not a strictly accurate way of viewing the matter. The majority of semiconductor manufacturers now warn against getting any semiconductor components close to large static charges.

While semiconductors are mostly untroubled by short bursts of high current, excessive voltages, even when extremely short in duration, tend to damage components sufficiently to leave them in an unusable state. Whether the source of the voltage is a static charge or a normal power source such as a battery is of no practical importance. Either way, a suitably high potential will result in damage to a semiconductor component.

Therefore, it is advisable to keep all semiconductor components away from possible sources of high voltage static charges. If you have any prolific generators of static electricity in your home you will probably be all too aware of them already. Common sources are TV sets, computer monitors, carpets, and pets. It is perhaps worth pointing out that although loose components are the most vulnerable, it is still possible for damage to occur once components have been fitted onto a circuit board. The components should be safe once the circuit board has been housed in a case, but the semiconductors it contains remain vulnerable until it is protected by some form of housing.

At risk

Practically all semiconductors are to some extent vulnerable to static charges, but it is certainly the MOS types that are at the greatest risk. It is quite normal for an MOS device to have an extremely high input resistance of a million megohms or more. The equivalent figure for ordinary bipolar transistors is more like a few kilohms, which quickly leaks away any static charges long before dangerously high potentials are reached. By contrast, the input resistance is so high for MOS devices that, even over a period of time, static charges are not significantly leaked away. Instead, they are left to build up, possibly reaching such a high potential that the device breaks down and is destroyed.

It is important to realise that MOS components can be damaged by relatively small static voltages, and that we are not necessarily talking in terms of a few hundred volts or more with sparks flying. Voltages of sufficient magnitude to damage MOS devices are often found in everyday environments, but these voltages are often too low to make their presence obvious. You can pick up an MOS component and accidentally zap it without there being any noticeable sign of a problem. You only become aware that all is not well when the completed project fails to work.

Sent packing

Vulnerable devices should be supplied in some form of anti-static packing, and they are completely safe from static charges while they are kept in this packaging. There are several forms of anti-static packing in common use, including conductive foam, blister packs, plastic tubes, and conductive plastic bags. Some typical examples of anti-static packing are shown in Fig.2.

Fig.2. Three types of anti-static packaging. Blister pack (top left), conductive foam (top right), and a conductive plastic bag (bottom)

There are two basic approaches to protecting the components, and one of these is to 'short-circuit' all the pins or leads of the components together. While this does not actually keep high voltages at bay, it prevents a high voltage from existing between two of the component's terminals. This has the desired effect because it is not a high voltage *per se* that causes the damage. It is a high voltage between two pins that 'blows' one or more semiconductor junctions and destroys the device.

The second approach is to insulate components from the outside world, and this is the one taken with the plastic tubes. The blister packs that have a conductive foil backing take a 'belt and braces' approach, with both types of protection being provided.

Unnecessary handling of MOS devices should obviously be avoided, and they should be left in their anti-static packaging until it is time for them to be fitted to the circuit board. Semiconductors sometimes come complete with various warning notices which imply that the components have no chance of survival unless they are handled in an environment that is protected by some very expensive anti-static equipment.

These notices tend to exaggerate the problem though, and it is certainly not essential to use expensive equipment, even when dealing with the most vulnerable components. This is just as well, since a few simple precautions are the only option available to most electronic hobbyists.

An important precaution is to keep the components well away from any known or likely sources of static charges. In a similar vein, when building projects do not wear clothes that might generate static charges. These days, manmade fibres are normally mixed with natural fibres, and this has made the problem far less common than it used to be. However, if you have any clothes that shown any signs of producing static charges; do not wear them when building electronic projects.

Another important precaution is to fit integrated circuits to the circuit board via sockets. This is definitely advisable with any integrated circuits, MOS or otherwise, but it is essential with the MOS variety.

Always try to avoid touching the pins any more than is absolutely necessary when fitting semiconductors to a circuit board. Unfortunately, it will not usually be possible to avoid touching them altogether. It might be possible if you have an integrated circuit insertion tool, but there will still be the occasional awkward component that requires some straightening of the pins by hand before it will fit into the holder.

Down to earth

Although much of the available anti-static equipment is probably too expensive for serious consideration by amateur users, there are two items that are practical propositions. Both rely on the fact that static charges can be removed by leaking them away to 'earth'. An earthing wristband almost certainly represents the most cost-effective item of anti-static equipment. In addition to the wristband itself, there is an earthing plug, and a lead to connect this to the wristband (Fig.3).

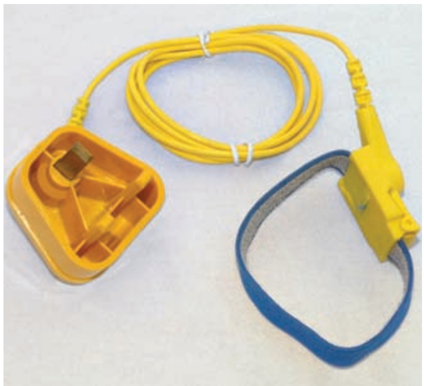


Fig.3. An earthing wristband can be obtained quite cheaply these days, and enables sensitive components to be handled without fear of zapping them

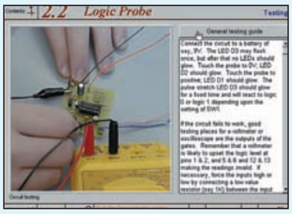
The plug looks a bit like an ordinary mains plug, but it only carries an earth connection, and the other two pins are dummies made from plastic. There is probably no realistic chance of getting a severe electric shock from one of these devices, but a high value protection resistor is included in the lead anyway.

An earthing mat can be used on the workbench, and it is simply a mat made from a conductive material that is earthed in the same way as an earthing wristband. The presence of the mat guarantees that there can be no build-up of static charges in the work area. Anything brought into the work area should be placed on the mat, where any static charges will be earthed before they have a chance to cause any problems.

EPE IS PLEASED TO BE ABLE TO OFFER YOU THESE

ELECTRONICS CD-ROMS

ELECTRONICS PROJECTS



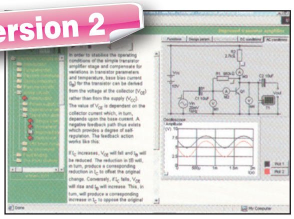
Logic Probe testing

Electronic Projects is split into two main sections: **Building Electronic Projects** contains comprehensive information about the components, tools and techniques used in developing projects from initial concept through to final circuit board production. Extensive use is made of video presentations showing soldering and construction techniques. The second section contains a set of ten projects for students to build, ranging from simple sensor circuits through to power amplifiers. A shareware version of Matrix's CADPACK **schematic capture, circuit simulation** and **p.c.b. design** software is included.

The projects on the CD-ROM are: Logic Probe; Light, Heat and Moisture Sensor; NE555 Timer; Egg Timer; Dice Machine; Bike Alarm; Stereo Mixer; Power Amplifier; Sound Activated Switch; Reaction Tester. Full parts lists, schematics and p.c.b. layouts are included on the CD-ROM.

ELECTRONIC CIRCUITS & COMPONENTS V2.0

Version 2

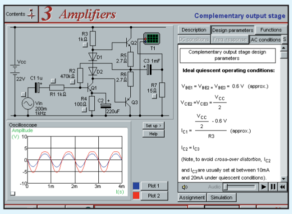


Circuit simulation screen

Electronics Circuits & Components V2.0 provides an introduction to the principles and application of the most common types of electronic components and shows how they are used to form complete circuits. The virtual laboratories, worked examples and pre-designed circuits allow students to learn, experiment and check their understanding. Version 2 has been considerably expanded in almost every area following a review of major syllabuses (GCSE, GNVQ, A level and HNC). It also contains both European and American circuit symbols. Sections include: ***Fundamentals***: units and multiples, electricity, electric circuits, alternating circuits. ***Passive Components***: resistors, capacitors, inductors, transformers. ***Semiconductors***: diodes, transistors, op amps, logic gates. ***Passive Circuits. Active Circuits***. *The Parts Gallery* will help students to recognise common electronic components and their corresponding symbols in circuit diagrams.

Included in the Institutional Versions are multiple choice questions, exam style questions, fault finding virtual laboratories and investigations/worksheets.

ANALOGUE ELECTRONICS



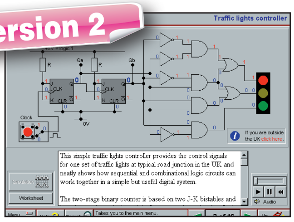
Complimentary output stage

Analogue Electronics is a complete learning resource for this most difficult branch of electronics. The CD-ROM includes a host of virtual laboratories, animations, diagrams, photographs and text as well as a SPICE electronic circuit simulator with over 50 pre-designed circuits.

Sections on the CD-ROM include: ***Fundamentals*** – Analogue Signals (5 sections),Transistors (4 sections), Waveshaping Circuits (6 sections). ***Op Amps*** – 17 sections covering everything from Symbols and Signal Connections to Differentiators. ***Amplifiers*** – Single Stage Amplifiers (8 sections), Multi-stage Amplifiers (3 sections). ***Filters*** – Passive Filters (10 sections), Phase Shifting Networks (4 sections), Active Filters (6 sections). ***Oscillators*** – 6 sections from Positive Feedback to Crystal Oscillators. ***Systems*** – 12 sections from Audio Pre-Amplifiers to 8-Bit ADC plus a gallery showing representative p.c.b. photos.

DIGITAL ELECTRONICS V2.0

Version 2



Virtual laboratory - Traffic Lights

Digital Electronics builds on the knowledge of logic gates covered in *Electronic Circuits & Components* (above), and takes users through the subject of digital electronics up to the operation and architecture of microprocessors. The virtual laboratories allow users to operate many circuits on screen.

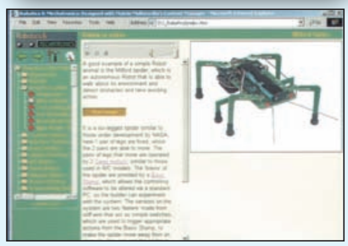
Covers binary and hexadecimal numbering systems, ASCII, basic logic gates, monostable action and circuits, and bistables – including JK and D-type flip-flops. Multiple gate circuits, equivalent logic functions and specialised logic functions. Introduces sequential logic including clocks and clock circuitry, counters, binary coded decimal and shift registers. A/D and D/A converters, traffic light controllers, memories and microprocessors – architecture, bus systems and their arithmetic logic units. Sections on Boolean Logic and Venn diagrams, displays and chip types have been expanded in Version 2 and new sections include shift registers, digital fault finding, programmable logic controllers, and microcontrollers and microprocessors. The Institutional versions now also include several types of assessment for supervisors, including worksheets, multiple choice tests, fault finding exercises and examination questions.

ANALOGUE FILTERS

Filter synthesis

Analogue Filters is a complete course in designing active and passive filters that makes use of highly interactive virtual laboratories and simulations to explain how filters are designed. It is split into five chapters: **Revision** which provides underpinning knowledge required for those who need to design filters. **Filter Basics** which is a course in terminology and filter characterization, important classes of filter, filter order, filter impedance and impedance matching, and effects of different filter types. **Advanced Theory** which covers the use of filter tables, mathematics behind filter design, and an explanation of the design of active filters. **Passive Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev ladder filters. **Active Filter Design** which includes an expert system and filter synthesis tool for the design of low-pass, high-pass, band-pass, and band-stop Bessel, Butterworth and Chebyshev op.amp filters.

ROBOTICS & MECHATRONICS



Case study of the Milford Instruments Spider

Robotics and Mechatronics is designed to enable hobbyists/students with little previous experience of electronics to design and build electromechanical systems. The CD-ROM deals with all aspects of robotics from the control systems used, the transducers available, motors/actuators and the circuits to drive them. Case study material (including the NASA Mars Rover, the Milford Spider and the Furby) is used to show how practical robotic systems are designed. The result is a highly stimulating resource that will make learning, and building robotics and mechatronic systems easier. The Institutional versions have additional worksheets and multiple choice questions.

- Interactive Virtual Laboratories
- Little previous knowledge required
- Mathematics is kept to a minimum and all calculations are explained
- Clear circuit simulations

PRICES

Prices for each of the CD-ROMs above are:

(Order form on third page)

Hobbyist/Student	£45	inc VAT
Institutional (Schools/HE/FE/Industry)	£99	plus VAT
Institutional 10 user (Network Licence)	£249	plus VAT
Site licence	£499	plus VAT

(UK and EU customers add VAT at 15% to 'plus VAT' prices)

PICmicro TUTORIALS AND PROGRAMMING

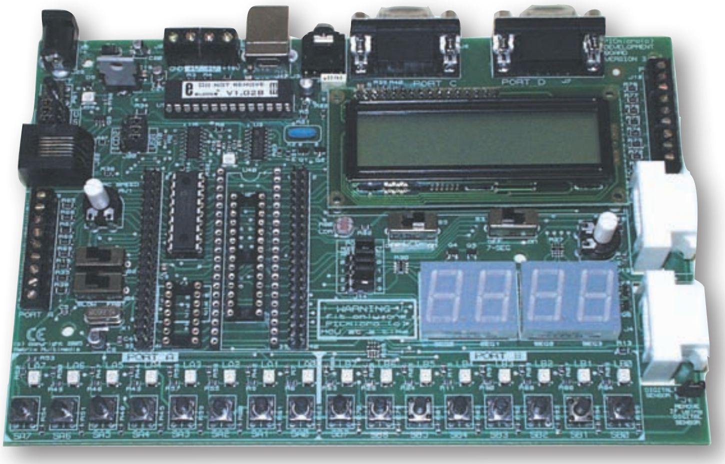
HARDWARE

VERSION 3 PICmicro MCU development board

Suitable for use with the three software packages listed below.

This flexible development board allows students to learn both how to program PICmicro microcontrollers as well as program a range of 8, 18, 28 and 40-pin devices from the 12, 16 and 18 series PICmicro ranges. For experienced programmers all programming software is included in the PPP utility that comes with the development board. For those who want to learn, choose one or all of the packages below to use with the Development Board.

- Makes it easier to develop PICmicro projects
- Supports low cost Flash-programmable PICmicro devices
- Fully featured integrated displays – 16 individual LEDs, quad 7-segment display and alphanumeric LCD display
- Supports PICmicro microcontrollers with A/D converters
- Fully protected expansion bus for project work
- USB programmable
- Can be powered by USB (no power supply required)



£158 including VAT and postage, supplied with USB cable and programming software

SOFTWARE

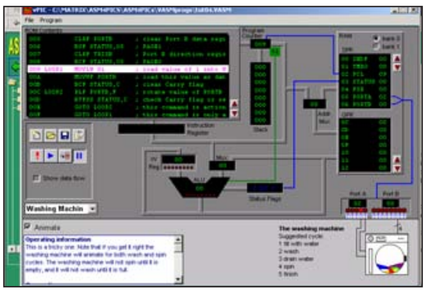
ASSEMBLY FOR PICmicro V3

(Formerly PICtutor)

Assembly for PICmicro microcontrollers V3.0 (previously known as PICtutor) by John Becker contains a complete course in programming the PIC16F84 PICmicro microcontroller from Arizona Microchip. It starts with fundamental concepts and extends up to complex programs including watchdog timers, interrupts and sleep modes.

The CD makes use of the latest simulation techniques which provide a superb tool for learning: the Virtual PICmicro microcontroller, this is a simulation tool that allows users to write and execute MPASM assembler code for the PIC16F84 microcontroller on-screen. Using this you can actually see what happens inside the PICmicro MCU as each instruction is executed, which enhances understanding.

● Comprehensive instruction through 45 tutorial sections ● Includes Vlab, a Virtual PICmicro microcontroller: a fully functioning simulator ● Tests, exercises and projects covering a wide range of PICmicro MCU applications ● Includes MPLAB assembler ● Visual representation of a PICmicro showing architecture and functions ● Expert system for code entry helps first time users ● Shows data flow and fetch execute cycle and has challenges (washing machine, lift, crossroads etc.) ● Imports MPASM files.

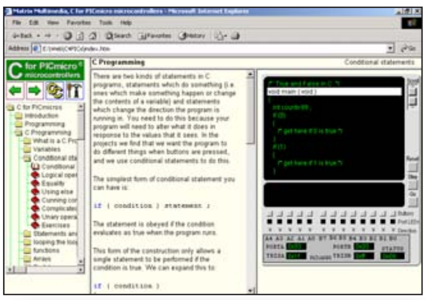


'C' FOR 16 Series PICmicro Version 4

The C for PICmicro microcontrollers CD-ROM is designed for students and professionals who need to learn how to program embedded microcontrollers in C. The CD-ROM contains a course as well as all the software tools needed to create Hex code for a wide range of PICmicro devices – including a full C compiler for a wide range of PICmicro devices.

Although the course focuses on the use of the PICmicro microcontrollers, this CD-ROM will provide a good grounding in C programming for any microcontroller.

● Complete course in C as well as C programming for PICmicro microcontrollers ● Highly interactive course ● Virtual C PICmicro improves understanding ● Includes a C compiler for a wide range of PICmicro devices ● Includes full Integrated Development Environment ● Includes MPLAB software ● Compatible with most PICmicro programmers ● Includes a compiler for all the PICmicro devices.



Minimum system requirements for these items: Pentium PC running, 2000, ME, XP; CD-ROM drive; 64MB RAM; 10MB hard disk space.
Flowcode will run on XP or later operating systems

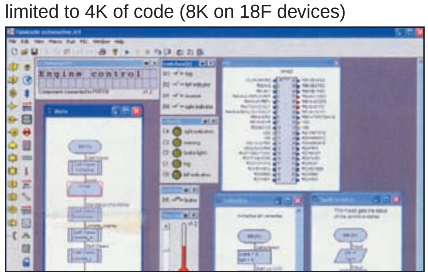
FLOWCODE FOR PICmicro V4

FREE with Flowcode V4 (student and institutional versions) ECIO board – a 28-pin reprogrammable microcontroller.

Flowcode is a very high level language programming system based on flowcharts. Flowcode allows you to design and simulate complex systems in a matter of minutes. A powerful language that uses macros to facilitate the control of devices like 7-segment displays, motor controllers and LCDs. The use of macros allows you to control these devices without getting bogged down in understanding the programming. When used in conjunction with the Version 3 development board this provides a seamless solution that allows you to program chips in minutes.

● Requires no programming experience ● Allows complex PICmicro applications to be designed quickly ● Uses international standard flow chart symbols ● Full on-screen simulation allows debugging and speeds up the development process.

● Facilitates learning via a full suite of demonstration tutorials ● Produces ASM code for a range of 18, 28 and 40-pin devices ● 16-bit arithmetic strings and string manipulation ● pulse width modulation ● I2C. New features of Version 4 include panel creator, in circuit debug, virtual networks, C code customisation, floating point and new components. The Hobbyist/Student version is limited to 4K of code (8K on 18F devices)



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Hobbyist/Student	**£45**	**inc VAT**
Institutional (Schools/HE/FE/Industry)	**£99**	**plus VAT**
Institutional/Professional 10 user (Network Licence)	**£350**	**plus VAT**
Site Licence	**£699**	**plus VAT**
Flowcode Institutional (Schools/HE/FE/Industry)	**£149**	**plus VAT**
Flowcode 10 user (Network Licence)	**£399**	**plus VAT**
Flowcode Site Licence	**£799**	**plus VAT**

SPECIAL PACKAGE OFFER

TINA Pro V7 (Basic) + Flowcode V3 (Hobbyist/Student)

£58.00 inc. VAT and p&p

TINA Analogue, Digital, Symbolic, RF, MCU and Mixed-Mode Circuit Simulation, Testing and PCB Design

TINA Design Suite is a powerful yet affordable software package for analysing, designing and real time testing analogue, digital, MCU, and mixed electronic circuits and their PCB layouts. You can also analyse RF, communication, optoelectronic circuits, test and debug microcontroller applications.

Enter any circuit (up to 100 nodes) within minutes with TINA's easy-to-use schematic editor. Enhance your schematics by adding text and graphics. Choose components from the large library containing more than 10,000 manufacturer models. Analyse your circuit through more than 20 different analysis modes or with 10 high tech virtual instruments. Present your results in TINA's sophisticated diagram windows, on virtual instruments, or in the live interactive mode where you can even edit your circuit during operation.

Customise presentations using TINA's advanced drawing tools to control text, fonts, axes, line width, colour and layout. You can create, and print documents directly inside TINA or cut and paste your results into your favourite word- procesing or DTP package.

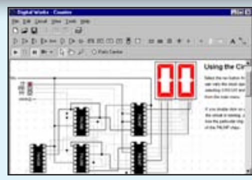
TINA includes the following Virtual Instruments: Oscilloscope, Function Generator, Multimeter, Signal Analyser/Bode Plotter, Network Analyser, Spectrum Analyser, Logic Analyser, Digital Signal Generator, XY Recorder.

***Flowcode V3** (Hobbyist/Student) – For details on Flowcode, see the previous page.*

This offer gives you two seperate CD-ROMs – the software will need registering (FREE) with Designsoft (TINA) and Matrix Multimedia (Flowcode), details are given within the packages.

Get TINA + Flowcode for a total of just £58, including VAT and postage.

DIGITAL WORKS 3.0



Counter project

Digital Works Version 3.0 is a graphical design tool that enables you to construct digital logic circuits and analyze their behaviour. It is so simple to use that it will take you less than 10 minutes to make your first digital design. It is so powerful that you will never outgrow its capability ● Software for simulating digital logic circuits ● Create your own macros – highly scalable ● Create your own circuits, components, and i.c.s ● Easy-to-use digital interface ● Animation brings circuits to life ● Vast library of logic macros and 74 series i.c.s with data sheets ● Powerful tool for designing and learning.

Hobbyist/Student £45 inc. VAT.
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PROJECT DESIGN WITH CROCODILE TECHNOLOGY

An Interactive Guide to Circuit Design

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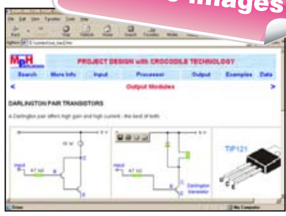
An interactive CD-ROM to guide you through the process of circuit design. Choose from an extensive range of input, process and output modules, including CMOS Logic, Op-Amps, PIC/PICAXE, Remote Control Modules (IR and Radio), Transistors, Thyristors, Relays and much more.
Click Data for a complete guide to the pin layouts of i.c.s, transistors etc. Click More Information for detailed background information with many animated diagrams.
Nearly all the circuits can be instantly simulated in Crocodile Technology (not included on the CD-ROM) and you can customise the designs as required.*



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Light Modules, Temperature Modules, Sound Modules, Moisture Modules, Switch Modules, Astables including 555, Remote Control (IR & Radio), Transistor Amplifiers, Thyristor, Relay, Op-Amp Modules, Logic Modules, 555 Timer, PIC/PICAXE, Output Devices, Transistor Drivers, Relay Motor Direction & Speed Control, 7 Segment Displays.Data sections with pinouts etc., Example Projects, Full Search Facility, Further Background Information and Animated Diagrams.
Runs in Microsoft Internet Explorer
All circuits can be viewed, but can only be simulated if your computer has Crocodile Technoloy version 410 or later. A free trial version of Crocodile Technology can be downloaded from: **www.crocodile-clips.com. Animated diagrams run without Crocodile Technology.*

Single User £39.00 inc. VAT.
Multiple Educational Users (under 500 students) £59.00 plus VAT. Over 500 students £79.00 plus VAT.
(UK and EU customers add VAT at 15% to "plus VAT" prices)

Minimum system requirements for these CD-ROMs: Pentium PC, CD-ROM drive, 32MB RAM, 10MB hard disk space. Windows 2000/ME/XP, mouse, sound card, web browser.

ELECTRONIC COMPONENTS PHOTOS

A high quality selection of over 200 jpg images of electronic components. This selection of high resolution photos can be used to enhance projects and presentations or to help with training and educational material. They are royalty free for use in commercial or personal printed projects, and can also be used royalty free in books, catalogues, magazine articles as well as worldwide web pages (subject to restrictions – see licence for full details).
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☐ Assembly for PICmicro V3
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☐ Flowcode V4 for PICmicro + ECIO
☐ Digital Works 3.0

Version required:
☐ Hobbyist/Student
☐ Institutional
☐ Institutional/Professional 10 user
☐ Site licence

Note: The software on each version is the same, only the licence for use varies.

☐ PICmicro Development Board V3 (hardware)

☐ TINA Pro V7 Basic + Flowcode V3 Hobbyist/Student
☐ Electronic Components Photos; Version 1.1
☐ Project Design – Single User
☐ Project Design – Multiple User (under 500 students)
☐ Project Design – Multiple User (over 500 students)

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READOUT

Email: editorial@wimborne.co.uk

Matt Pulzer addresses some of the general points readers have raised. Have you anything interesting to say? Drop us a line!

All letters quoted here have previously been replied to directly

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★ LETTER OF THE MONTH ★

Short circuit test warning

Dear Editor

I am concerned at some of the comments made in the January 2010 issue of *EPE* in the *Ingenuity Unlimited* item 'Wartbox' about plug top ('wall-wart') power supply units (PSU).

The writer suggests shorting the output to determine the output current. Depending on the design of the circuit in the PSU, this is not normally a good idea. You could damage it and the resulting current value will be the short-circuit value, not the normal maximum rated output current.

These plug-top PSUs come in five types:

- Transformer unit – contains a transformer only, markings should show output is AC.
- Unregulated unit – contains transformer, rectifier and smoothing capacitor; output is DC, but is unregulated. With no load, or a low current load, the output voltage will be much higher than the rated output voltage, because the capacitor charges up to the peak voltage of the secondary of the transformer (about 1.4 times the transformer secondary RMS voltage). The marked voltage on the unit is normally the voltage when the rated current is being delivered. To estimate the voltage at the rated current, divide the off-load voltage by 1.28.
- Regulated unit – transformer, rectifier, smoothing capacitors and linear regulator circuit. Provided the unit stays within its current rating, the voltage is constant and independent of load.
- Switched-mode type that uses a mains transformer – similar to the linear regulated unit, but uses a switched-mode regulator circuit. Again, within its current rating, the voltage is constant and independent of load.
- Switched-mode type that directly uses the mains voltage. This type does not use a normal mains transformer (and is therefore smaller and lighter). Instead, it rectifies the mains to produce about 330V DC (when used on 230V AC mains supplies) and then converts this to a high frequency AC current, which is fed to a high frequency transformer. The output is rectified and smoothed. The result is a regulated DC output.

Some regulated units and switched-mode types have current-limiting protection, and/or short-circuit protection. However, the other PSUs normally only have a thermal fuse (and some of the really cheap imported ones don't even have that). The fuse is part of the transformer and is not replaceable; once 'blown', the unit is scrap.

In the types that don't have a regulator circuit to limit the current (until the thermal fuse 'blows'), the only component that provides any limiting factor is the transformer. But these are cheap transformers, and by shorting the output you are putting them under a great deal of stress – not recommended.

Mark Kinsey,
Weston-super-Mare, by email

Useful advice Mark, and thank you for the overview of the 'wall-wart' types. Plus, I'd like to reiterate that readers should only tackle this kind of mains-based work if they are quite clear they understand the dangers and correct use of mains electricity.

Soldering advice

Dear Editor

Having read Alan Winstanley's soldering guide on the internet, I have to congratulate him. Everything I've ever read flies straight into 'solder this item to that'. This was the first time I encountered anything sensible on the art of soldering, and anyone new to electronics needs to read this prior to attempting any soldering project.

I have worked with stained glass extensively over a period of time, so I have a fair amount of soldering experience, although of a totally different nature. This type of fine soldering with limited heat input is new to me, so thank you again for providing me with this helpful guide.

Chris Watkins, South Africa,
by email

We're glad to be of help! Other readers can access Alan's advice at: ***www.epemag.wimborne.co.uk/solderfaq.htm***

Thanks for thanks!

Dear Editor

Many thanks for the 'Honourable mention' in December's issue, your comment is most kind and I must say that I and Chris, my 'tother half, are really touched (but she's not surprised as I'm always trying to help mend things for people!). I'm sure that if John Becker had been alive, he'd have approved too.

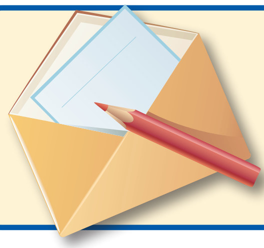
From the technical point of view, this was a first-time experience for me because I mended Terry Buchanan's exposure meter by remote control! I never had the physical equipment, only photographs sent by email. (What Terry lacks in electronic knowledge, he certainly makes up for in his mastery of photography.)

I did email the manufacturer for circuit details, but all I got back was a firm refusal written in polite German.

Ah well, not everyone wants to help.

Godfrey Manning,
Edgware, by email

Again, well done Godfrey! – troubleshooting is always tricky, but you succeeded without having access to the equipment in question and a polite if unhelpful brush off from the manufacturer.



IF YOU HAVE A SUBJECT YOU WISH TO DISCUSS ON THIS PAGE
PLEASE EMAIL US AT:
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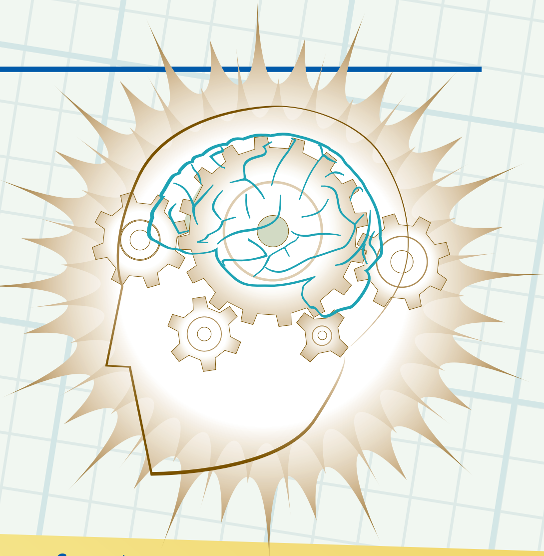
Ingenuity Unlimited

Our regular round-up of readers' own circuits



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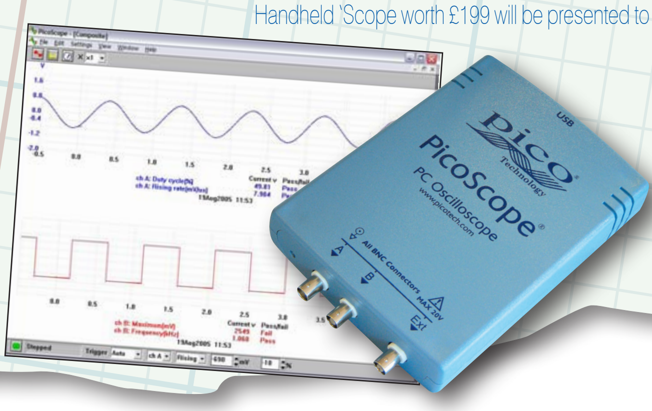


We pay between £10 and £50 for all material published, depending on length and technical merit. We're looking for novel applications and circuit designs, not simply mechanical, electrical or software ideas. Ideas must be the reader's own work and **must not have been published or submitted for publication elsewhere.**

The circuits shown have NOT been proven by us. **Ingenuity Unlimited** is open to ALL abilities, but items for consideration in this column should be typed or word-processed, with a brief circuit description (between 100 and 500 words maximum) and include a full circuit diagram showing all component values. **Please draw all circuit schematics as clearly as possible.** Send your circuit ideas to: Ingenuity Unlimited, Wimborne Publishing Ltd., Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU. Email: editorial@epemag.wimborne.co.uk.

Your ideas could earn you some cash **and a prize** !

Spectra-Lite II – *a colourful display*

In February 1992, *EE* magazine published the *Spectra-Lite*, a colourful LED display which enabled one to advertise one's hobby (electronics) on one's lapel. This circuit, claimed *EE*, would have people 'intrigued and speechless'.

The circuit of Fig.1 accomplishes much the same as the Spectra-Lite, only in a more simple fashion, continually cycling a tri-colour LED (LED1/LED2) through red, orange, green, and back again.

How it works

The circuit which surrounds IC1a is a simple clock generator, which produces a slow sawtooth waveform at input pin 1, and a squarewave waveform at output pin 2. IC1b and IC1c are wired in parallel to boost output current. This circuit is repeated, except in inverted form, by IC1f. A sawtooth waveform is produced at the junction of resistor R3 and capacitor C3, while a squarewave waveform is produced at output pin 12. Again, IC1d and IC1e are used to boost output current. In short, while the voltage at IC1a input pin 1 rises, so the voltage at IC1f input pin 13 falls, and vice versa.

The resistors which charge and discharge timing capacitors C2 and C3 (R2 and R3 respectively) are of a sufficiently low value to illuminate an LED, while simultaneously charging and discharging C2 and C3. Zener diodes ZD1 and ZD2 drop 3V each, so as to adjust the voltage across LED1/LED2 downward to a suitable level for controlling the brightness of these two LEDs. If desired, 1N4001 diodes may be wired in series with Zener diodes ZD1 and ZD2 to tweak the performance of the LEDs.

The circuit requires a number of 'ground rules' in order to work. Resistor R1 and R4 should have significantly higher values than R2 and R3, or capacitors C2 and C3 will fail to charge. R1 and R4, calculated in series with R2 and R3, should have sufficiently low values to illuminate the LEDs brightly. Capacitors C2 and C3 should have sufficiently high values to keep the values of R2 and R3 low, though not too low, so as not to overload IC1. Components surrounding IC1a and IC1f should ideally be matched.

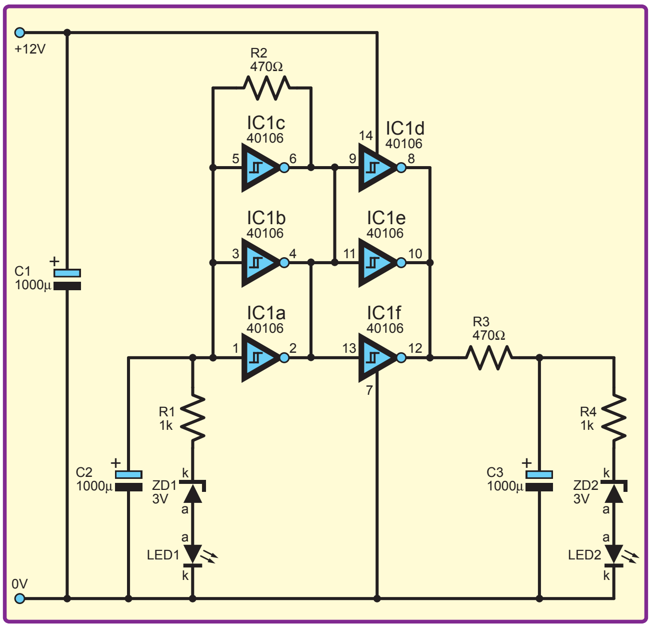


Fig.1. Complete circuit diagram for the Mk2 version of the Spectra-Lite

After switch-on, C3 requires a few cycles longer than C2 to attain its full charge and discharge cycle. The circuit has a moderate current consumption at about 20mA. The tri-colour LED is a dual red/green type in a single package, with a common cathode (k).

Thomas Scarborough
Cape Town, South Africa

Max's Cool Beans

By Max The Magnificent

Book it!

WELL, I'm a very happy person at the moment, because my wife – Gina the Gorgeous – presented me with my first 'toy' based on electronic paper as my Christmas present this year. Much to my surprise, she gave me a Kindle electronic book reader from Amazon (**www.amazon.com/gp/product/B0015T963C**). Meanwhile, my 15-year old son gave me a leather cover for the little rascal (by which I mean my Kindle, not my wife), and the two dogs and the cat – Henri, Lili, and Rocket, respectively – surprised me with a clip-on LED-based night light (at least, that's what it said on the wrapping paper; goodness only knows where they got the money).

I've been pondering buying one of these little beauties for ages and ages, but I never took the plunge ... now I'm kicking myself that I waited so long. At the time of writing, there are two models available. Gina gave me the smaller version that is 203mm (8in) tall, 135mm (5.3in) wide, and 9mm (0.36in) thick, with a 152mm (6in) diagonal display. This really is amazing. It's about the same size (area-wise) as a typical paperback book and only as thick as a pencil – see photo. It's also incredibly light; even with its leather cover (not shown here), it weighs only about as much as a regular paperback book.

This version holds about 1500 books and has international wireless capability that works in about 100 countries around the globe. The great thing here is that you don't have to sign up for a wireless service or anything – it just comes with the Kindle, with no monthly fees and no annual contracts. Also, you don't need to go hunting for a 'wireless hotspot' – it works pretty much wherever you are, just like a cellphone.

Not surprisingly, when the wireless is on, it does tend to drain the battery faster than when it's off, but you only need the wireless to be powered-up when you are searching the Amazon store (or the rest of the web) and when you are downloading a book or a magazine or whatever. Once you've loaded any items you wish to read onto your Kindle, you can turn the wireless off (I make a point of deactivating the wireless when I'm not using it). I've been using my Kindle for an average of about one hour a day; and after two weeks it still shows that the battery is half full from its original charge, which I think is jolly impressive.

Now, in order to download books you do need to have an account at Amazon, but I already had one (I typically purchase two or three books a week), so all I had to do was enter my account details (user name and password) into the Kindle, and I was ready to 'rock and roll' and download my first book.

I decided to dip my toes in the water with a recent science fiction book, which would have sported a price-tag of around $10 (£6) as a physical paperback book, but which cost only $6 (£4) in its electronic incarnation. The download took less than a minute, after which I was up and running.

Good experience

To be honest, the reason I had held back from purchasing a Kindle in the past was that I wasn't sure how good the 'user experience' would be. As it happens, I'm delighted to report that it's great; plus, there are all sorts of advantages to the electronic version, such as the fact that you can change the size of the font on the fly. Also there's an inbuilt dictionary, so if you are unsure of a word, you can move a cursor over it and an associated dictionary definition immediately pops up. Also, you can set electronic bookmarks, add notes, cut out clippings... and the list goes on.

There's also a larger version of the Kindle – the Kindle DX (**www.amazon.com/Kindle-Wireless-Reading-Display-Generation/dp/B0015TG12Q**) – that may be more appropriate for some folks. This really does look rather tasty; it has a much bigger display screen and it can hold up to 3500 books, periodicals and other items.

This little beauty also offers some cool features like an auto-rotating screen, which means that the display auto-rotates from portrait to landscape as you turn the device, thereby allowing you to easily view full-width maps, graphs, tables, and web pages (you have to set this manually on the smaller model).

I was going to say that the main downside to the Kindle DX (apart from its substantially higher price-tag) is the fact that its wireless works only in the US, but I just bounced over to Amazon and I see that the latest version now has global wireless capability. In fact, I just clicked the 'Coverage Map' link on Amazon, and I see that just about every country I'm every likely to visit is covered for both Kindles, including India, where I will be presenting a number of papers at a conference this coming summer (I'll tell you more about that in a future column).

Of course, there will always be a place in my heart for real, physical books printed on paper, but when it comes to travelling to visit my mom in the UK, or jetting around the globe to 'do stuff', from this point on I think I will be carrying only my Kindle.

Check out 'The Cool Beans Blog' at www.epemag.com

Catch up with Max and his up-to-date topical discussions

Net Work

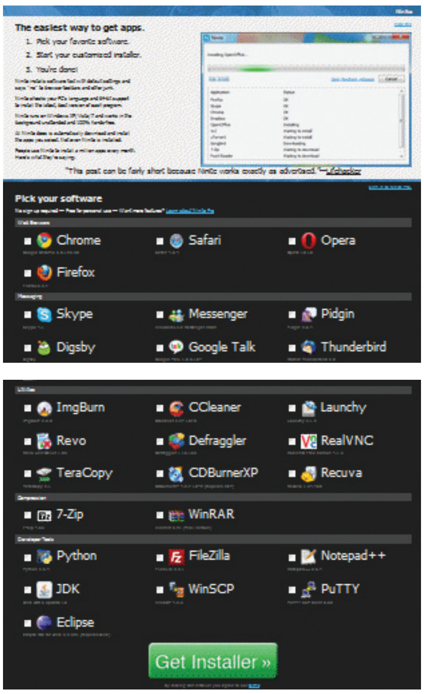
Alan Winstanley

This month, I'll start with a timely nag about taking backups: a recent near-total disaster involving a friend's IBM desktop server running RAID necessitated a full reinstallation of essential data and software. She depends entirely on her system for her business, and we were fortunate enough to recover data from the damaged hard disks. However, all software had to be reinstalled from scratch: you do keep serial numbers, log-ins and passwords safely locked away somewhere for such times, don't you? So consider off-site backups such as Carbonite, Netgear ReadyNAS Vault, or F-Secure Online Backup.

When rebuilding systems, a reader has suggested a useful online tool that helps with downloading and installing useful essential applications (apps). Ninite from **www.ninite.com** is a brilliant Windows fetcher and installer that provides a shopping list of all the best downloadable applications, including Firefox, AVG Anti Virus, Skype, MalwareBytes, CCleaner, Google Earth and very many more. Simply tick the apps. you want and the downloader is created automatically. Ninite is small, fast and light – not even Ninite is installed. Check their website for a list of available downloads, and why not suggest your own apps. too?

A flashy smartphone

Regular readers will know that I'm a big fan of my HTC Tytn II Windows Mobile phone, which allows me to check email on the move and surf the web with some limitations. This has only become more practical in the last year or so as network coverage has increased. Tariffs seem more generous too, with the networks striving to outdo each other in the scramble to poach customers from rivals. Despite the 'unlimited' GPRS or 3G data quotas now on offer, I still only download the first few kilobytes of an email just to get the feel, before fetching interesting-looking emails in full, individually.



A hugely useful downloader to help installing essential software is ***Ninite.com***

A few weeks ago my patience finally ran out with my provider (Orange) due to poor coverage and I felt the phone wasn't paying for itself. I migrated to rival 02, which provides a SIM only with a so-called unlimited data tariff on a 30-day rolling contract, without being locked into an 18- or 24-month contract. The data coverage is far better and now the phone is rapidly becoming indispensable, unchaining me from my office PC into the bargain as well!

Several weeks elapsed before Orange could unlock my phone, so a 95p SIM card from Tesco Mobile (which is powered by 02), dropped into an ancient Nokia phone, helped me over a transition period. eBay is a useful source of spares and chargers for such legacy hardware. I felt that an old Nokia car charger for £1 was also worth buying as a backup, because you never know when something might fail, as my IBM-desktop owning friend (above) found to her cost.

Oh no?

So now I have an Orange-supplied HTC Tytn II running on 02. A variety of websites such as **http://xda-developers.com** are dedicated to the technology of updating or 'flashing' phones with the latest ROM upgrade, but it seems a huge risk to take, just to scrub out an Orange splash screen and delete some trivial Orange customisation or other: a job for another day perhaps.

The more urgent problem of using 02's mobile data service then arose. I needed their network's Access Point Name (APN) so that my phone could utilise GPRS. Disappointingly, O2 refused to help, citing an 'unsupported handset' and suggesting that I ask the handset manufacturer instead! Once again, the web came to the rescue, and I must commend the UK website **www.filesaveas.com**, which listed all the necessary GPRS settings for all UK networks. Armed with this information, at last my reinvigorated phone sprang into life on the new network. I configured the AuthSMTP service settings to send mobile email, and a few test emails confirmed all was well.

Author's mobile phone screen displayed on a Windows desktop using MyMobiler free from ***www.mymobiler.com***

As an extra attraction, my TomTom satellite navigation and phone now work together perfectly via Bluetooth, thanks to a TomTom windscreen holder with built-in microphone scrounged off eBay. Also sourced via eBay (Argos Clearance Bargains, no less!) was an in-car 'safe' for storing my satnav in an impregnable box. And I finally had crystal clear hands-free calling as well.

More websurfing turned up some indispensable free software for use with my Windows smartphone. MyMobiler from **www.mymobiler.com** allows the phone screen to be viewed on the PC desktop; just connect via USB, start MyMobiler and the smartphone's display appears in a window pane. You can navigate around the phone using the mouse, play with the address book and dial out on the mobile with the keyboard's numpad. Where necessary, use the arrow keys instead of the D-pad on the phone.

MyMobiler claims to support Windows Mobile 2003, Mobile 5 and 6, and it worked immediately on my WM6.1 phone, though connecting it does start Microsoft Active Sync as well. (Newer versions of Windows utilise Microsoft Device Stage instead; more details from **http://windows.microsoft.com/en-GB/windows7/What-is-Device-Stage**)

You can email me at **alan@epemag.demon.co.uk**.

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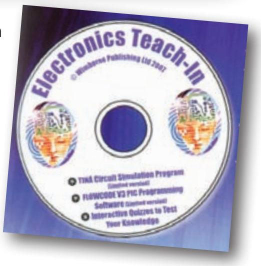
Electronics Teach-In CD-ROM



Mike Tooley

A broad-based introduction to electronics – find out how circuits work and what goes on inside them. The CD-ROM contains the whole *Teach-In 2006* series (originally published in *EPE*) in PDF form, plus interactive quizzes to test your knowledge, TINA circuit simulation software (a limited version – plus a specially written TINA Tutorial), together with simulations of the circuits in the *Teach-In* series, plus Flowcode (a limited version) a high level programming system for PIC microcontrollers based on flowcharts.

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Detailed building and programming instructions provided, including numerous step-by-step photographs.

288 pages - large format **Order code BP901** **£14.99**

MORE ADVANCED ROBOTICS WITH LEGO MINDSTORMS – Robert Penfold

Shows the reader how to extend the capabilities of the brilliant Lego Mindstorms Robotic Invention System (RIS) by using lego's own accessories and some simple home constructed units. You will be able to build robots that can provide you with 'waiter service' when you clap your hands, perform tricks, 'see' and avoid objects by using 'bats radar', or accurately follow a line marked on the floor. Learn to use additional types of sensors including rotation, light, temperature, sound and ultrasonic and also explore the possibilities provided by using an additional (third) motor. For the less experienced, RCX code programs accompany most of the featured robots. However, the more adventurous reader is also shown how to write programs using Microsoft's VisualBASIC running with the ActiveX control (Spirit.OCX) that is provided with the RIS kit.

Detailed building instructions are provided for the featured robots, including numerous step-by-step photographs. The designs include rover vehicles, a virtual pet, a robot arm, an 'intelligent' sweet dispenser and a colour conscious robot that will try to grab objects of a specific colour.

198 pages **Order code BP902** **£14.99**

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224 pages **Order code MGH1** **£16.99**

RADIO

BASIC RADIO PRINCIPLES AND TECHNOLOGY
Ian Poole

Radio technology is becoming increasingly important in today's high technology society. There are the traditional uses of radio which include broadcasting and point to point radio as well as the new technologies of satellites and cellular phones. All of these developments mean there is a growing need for radio engineers at all levels.

Assuming a basic knowledge of electronics, this book provides an easy to understand grounding in the topic.

Chapters in the book: Radio Today, Yesterday, and Tomorrow; Radio Waves and Propagation; Capacitors, Inductors, and Filters; Modulation; Receivers; Transmitters; Antenna Systems; Broadcasting; Satellites; Personal Communications; Appendix – Basic Calculations.

263 pages **Order code NE30** **£28.99**

PROJECTS FOR RADIO AMATEURS AND S.W.L.S.
R. A. Penfold

This book describes a number of electronic circuits, most of which are quite simple, which can be used to enhance the performance of most short wave radio systems.

The circuits covered include: An aerial tuning unit; A simple active aerial; An add-on b.f.o. for portable sets; A wavetrap to combat signals on spurious responses; An audio notch filter; A parametric equaliser; C.W. and S.S.B. audio filters; Simple noise limiters; A speech processor; A volume expander.

Other useful circuits include a crystal oscillator, and RTTY/C.W. tone decoder, and a RTTY serial to parallel converter. A full range of interesting and useful circuits for short wave enthusiasts.

92 pages **Order code BP304** **£4.45**

AN INTRODUCTION TO AMATEUR RADIO
I. D. Poole

Amateur radio is a unique and fascinating hobby which has attracted thousands of people since it began at the turn of the last century. This book gives the newcomer a comprehensive and easy to understand guide through the subject so that the reader can gain the most from the hobby. It then remains an essential reference volume to be used time and again. Topics covered include the basic aspects of the hobby, such as operating procedures, jargon and setting up a station. Technical topics covered include propagation, receivers, transmitters and aerials etc.

150 pages **Order code BP257** **£5.49**

COMPUTERS AND COMPUTING

ELECTRONICS TEACH-IN 2
USING PIC MICROCONTROLLERS
A PRACTICAL INTRODUCTION

FREE CD-ROM

This *Teach-In* series of articles was originally published in *EPE* in 2008 and, following demand from readers, has now been collected together in the *Electronics Teach-In 2* book.

The series is aimed at those using PIC microcontrollers for the first time. Each part of the series includes breadboard layouts to aid understanding and a simple programmer project is provided.

Also included are 29 *PIC N' Mix* articles, also republished from *EPE*. These provide a host of practical programming and interfacing information, mainly for those that have already got to grips with using PIC microcontrollers.

An extra four part beginners guide to using the C programing language for PIC microcontrollers is also included.

The free cover-mounted CD-ROM contains all of the software for the *Teach-In 2* series and *PIC N' Mix* articles in this book, plus a range of items from Microchip – the manufacturers of the PIC microcontrollers. The material has been compiled by Wimborne Publishing Ltd. with the assistance of Microchip Technology Inc.

The Microchip items are: MPLAB Integrated Development Environment V8.20; Microchip Advance Parts Selector V2.32; Treelink; Motor Control Solutions; 16-bit Embedded Solutions; 16-bit Tool Solutions; Human Interface Solutions; 8-bit PIC Microcontrollers; PIC24 Micrcontrollers; PIC32 Microcontroller Family with USB On-The-Go; dsPIC Digital Signal Controllers.

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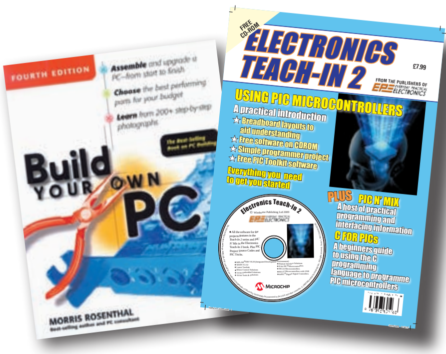

BUILD YOUR OWN PC – Fourth Edition
Morris Rosenthal

More and more people are building their own PCs. They get more value for their money, they create exactly the machine they want, and the work is highly satisfying and actually fun. That is, if they have a unique beginner's guide like this one, which visually demonstrates how to construct a computer from start to finish.

Through 150 crisp photographs and clear but minimal text, readers will confidently absorb the concepts of computer building. The extra-big format makes it easy to see what's going on in the pictures. The author goes 'under the hood' and shows step-by-step how to create a Pentium 4 computer or an Athlon 64 or Athlon 64FX, covering: What first-time builders need to know; How to select and purchase parts; How to assemble the PC; How to install Windows XP. The few existing books on this subject, although outdated, are in steady demand. This one delivers the expertise and new technology that fledgling computer builders are looking for.

224 pages - large format **Order code MGH2** **£16.99**

PROGRAMMING 16-BIT PIC MICROCONTROLLERS IN C – LEARNING TO FLY THE PIC24 Lucio Di Jasio (Application Segments Manager, Microchip, USA)

A Microchip insider tells all. Focuses on examples and exercises that show how to solve common, real-world design problems quickly. Includes handy checklists to help readers perform the most common programming and debugging tasks. FREE CD-ROM includes source code in C, the Microchip C30 compliler, and MPLAB SIM software, so that readers gain practical, hands-on programming experience.

Until recently, PICs didn't have the speed and memory necessary for use in designs such as video- and audio-enabled devices. All that changed with the introduction of the 16-bit PIC family, the PIC24. This new guide teaches readers everything they need to know about the architecture of these chips, how to program them, how to test them and how to debug them. Lucio's common-sense, practical, hands-on approach starts out with basic functions and guides the reader step-by-step through even the most sophisticated programming scenarios.

Experienced PIC users and newcomers alike will benefit from the text's many thorough examples, which demonstrate how to nimbly side-step common obstacles and take full advantage of all the 16-bit features.

496 pages +CD-ROM **Order code NE45** **£38.00**

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Andrew Edney

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Among the topics covered are: A brief overview of the various versions of Windows 7. How to install and use Upgrade Advisor, which checks to see if your computer meets the minimum requirements to run Windows 7 and that your software and drivers are supported by Windows 7. How to use Windows Easy Transfer to migrate your data and settings from your Vista or XP machine to your new Windows 7 computer. Exploring Windows 7 so that you will become familiar with many of its new features and then see how they contrast with those of earlier versions of Windows. How to connect to a network and create and use Home Groups to easily share your pictures, videos, documents, etc.,with the minimum of hassle. Why Windows Live Essentials is so useful and how to download and install it. A brief introduction to Windows Media Center. The use of Action Center, which reports security and maintenance incidents. Windows Memory Diagnostic to detect the fairly common problem of faulty memory and Troubleshooting tools.

120 pages **Order code BP708** **£8.49**

HOW TO BUILD A COMPUTER MADE EASY
R.A. Penfold

Building your own computer is a much easier than most people realise and can probably be undertaken by anyone who is reasonably practical. However, some knowledge and experience of using a PC would be beneficial. This book will guide you through the entire process. It is written in a simple and straightforward way with the explanations clearly illustrated with numerous colour photographs.

The book is divided into three sections: *Overview and preparation* – Covers understanding the fundamentals and choosing the most suitable component parts for your computer, together with a review of the basic assembly. *Assembly* – Explains in detail how to fit the component parts into their correct positions in the computer's casing, then how to connect these parts together by plugging the cables into the appropriate sockets. No soldering should be required and the only tools that you are likely to need are screwdrivers, small spanners and a pair of pliers.

BIOS and operating system – This final section details the setting up of the BIOS and the installation of the Windows operating system, which should then enable all the parts of your computer to work together correctly. You will then be ready to install your files and any application software you may require.

The great advantage of building your own computer is that you can 'tailor' it exactly to your own requirements. Also, you will learn a tremendous amount about the structure and internal workings of a PC, which will prove to be invaluable should problems ever arise.

120 pages **Order code BP707** **£8.49**

AN INTRDUCTION TO eBAY FOR THE OLDER GENERATION
Cherry Nixon

eBay is an online auction site that enables you to buy and sell practically anything from the comfort of your own home. eBay offers easy access to the global market at an amazingly low cost and will enable you to turn your clutter into cash.

This book is an introduction to eBay.co.uk and has been specifically written for the over 50s who have little knowledge of computing. The book will, of course, also apply equally to all other age groups. The book contains ideas for getting organised for long term safe and successful trading. You will learn how to search out and buy every conceivable type of thing.The book also shows you how to create auctions and add perfect pictures. There is advice on how to avoid the pitfalls that can befall the inexperienced.

Cherry Nixon is probably the most experienced teacher of eBay trading in the UK and from her vast experience has developed a particular understanding of the issues and difficulties normally encountered by individuals.

So, if you are new to computers and the internet and think of a mouse as a rodent, then this is the book for you!

120 pages **Order code BP709** **£8.49**

GETTING STARTED IN COMPUTING FOR THE OLDER GENERATION
Jim Gatenby

You can learn to use a computer at any age and this book will help you acheive this. It has been especially written for the over 50s, using plain English and avoiding technical jargon wherever possible. It is lavishly illustrated in full colour.

Among the many practical and useful subjects that are covered in this book are: Choosing the best computing system for your needs. Understanding the main hardware components of your computer. Getting your computer up and runnning in your home. Setting up peripheral devices like printers and routers. Connecting to the internet using wireless broadband in a home with one or more computers. Getting familiar with Windows Vista and XP the software used for operating and maintaining your computer. Learning about Windows built-in programs such as Windows Media Player, Paint and Photo Gallery.

Plus, using the Ease of Access Center to help if you have impaired eyesight, hearing or dexterity problems. Installing and using essential software such as Microsoft Office suite. Searching for the latest information on virtually any subject. Keeping in touch with friends and family using e-mail. Keeping your computer running efficiently and your valuable data files protected against malicious attack.

This book will help you to gain the basic knowledge needed to get the most out of your computer and, if you so wish, give you the confidence to even join a local computer class.

120 pages **Order code BP704** **£8.49**

THEORY AND REFERENCE

ELECTRONIC CIRCUITS – FUNDAMENTALS & APPLICATIONS
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Mike Tooley

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The unique combination of a comprehensive reference text, incorporating a primary focus on practical applications, ensures this text will prove a vital guide for students and also for industry-based engineers, who are either new to the field of electronics, or who wish to refresh their knowledge.

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Third Edition
Clive (Max) Maxfield

BOOK + CD-ROM

This book gives the 'big picture' of digital electronics. This indepth, highly readable, guide shows you how electronic devices work and how they're made. You'll discover how transistors operate, how printed circuit boards are fabricated, and what the innards of memory ICs look like. You'll also gain a working knowledge of Boolean Algebra and Karnaugh Maps, and understand what Reed-Muller logic is and how it's used. And there's much, MUCH more. The author's tongue-in-cheek humour makes it a delight to read, but this is a REAL technical book, extremely detailed and accurate. Comes with a free CD-ROM which contains an eBook version with full text search plus bonus chapter – An Illustrated History of Electronics and Computing.

Contents: Fundamental concepts; Analog versus digital; Conductors and insulators; Voltage, current, resistance, capacitance and inductance; Semiconductors; Primitive logic functions; Binary arithmetic; Boolean algebra; Karnaugh maps; State diagrams, tables and machines; Analog-to-digital and digital-to-analog; Integrated circuits (ICs); Memory ICs; Programmable ICs; Application-specific integrated circuits (ASICs); Circuit boards (PWBs and DWBs); Hybrids; Multichip modules (MCMs); Alternative and future technologies.

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Clive (Max) Maxfield and Alvin Brown

CD-ROM

This follow-on to Bebop to the Boolean Boogie is a multimedia extravaganza of information about how computers work. It picks up where "Bebop I" left off, guiding you through the fascinating world of computer design . . . and you'll have a few chuckles, if not belly laughs, along the way. In addition to over 200 megabytes of mega-cool multimedia, the CD-ROM contains a virtual microcomputer, simulating the motherboard and standard computer peripherals in an extremely realistic manner. In addition to a wealth of technical information, myriad nuggets of trivia, and hundreds of carefully drawn illustrations, the CD-ROM contains a set of lab experiments for the virtual microcomputer that let you recreate the experiences of early computer pioneers. if you're the slightest bit interested in the inner workings of computers, then don't dare to miss this!

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Third Edition
C. R. Robertson

Covers the essential principles that form the foundations for electrical and electronic engineering courses. The coverage of this new edition has been carefully brought in line with the core unit 'Electrical and Electronic Principles' of the 2007 BTEC National Engineering specification. This qualification from Edexcel attracts more than 10,000 students per year.

The book explains all theory in detail and backs it up with numerous worked examples. Students can test their understanding with end of chapter assignment questions for which answers are provided. In this new edition, the layout has been improved and colour has been added. A free companion website with additional worked examples and chapters is also available.

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Keith brindley

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A highly practical introduction for hobbyists, students, and technicians. Keith Brindley introduces readers to the functions of the main component types, their uses, and the basic principles of building and designing electronic circuits.

Breadboard layouts make this very much a ready-to-run book for the experimenter, and the use of multimeter, but not oscilloscopes, and readily available, inexpensive components makes the practical work achievable in a home or school setting as well as a fully equiped lab.

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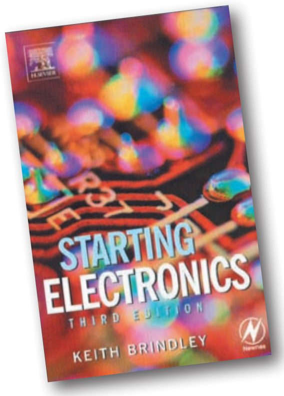

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You'll learn about recording techniques, software and effects, mixing, mastering and CD production.

Suitable for PC and Mac users, the book is full of tips, "how to do" topics and illustrations. It's the perfect answer to the question "How do I use my computer to produce my own CD?"

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Ian Waugh

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Whether you want to stay bang up to date with the latest music or create your own MP3s and join the on-line digital music revolution, this book will show you how.

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R. A. Penfold

Written by highly respected author R. A. Penfold, this book contains a collection of electronic projects specially designed for video enthusiasts. All the projects can be simply constructed, and most are suitable for the newcomer to project construction, as they are assembled on stripboard.

There are faders, wipers and effects units which will add sparkle and originality to your video recordings, an audio mixer and noise reducer to enhance your soundtracks and a basic computer control interface. Also, there's a useful selection on basic video production techniques to get you started.

Complete with explanations of how the circuit works, shopping lists of components, advice on construction, and guidance on setting up and using the projects, this invaluable book will save you a small fortune.

Circuits include: video enhancer, improved video enhancer, video fader, horizontal wiper, improved video wiper, negative video unit, fade to grey unit, black and white keyer, vertical wiper, audio mixer, stereo headphone amplifier, dynamic noise reducer, automatic fader, pushbutton fader, computer control interface, 12 volt mains power supply.

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This book is for complete beginners to electronic project building. It provides a complete introduction to the practical side of this fascinating hobby, including the following topics:

Component identification, and buying the right parts; resistor colour codes, capacitor value markings, etc; advice on buying the right tools for the job; soldering; making easy work of the hard wiring; construction methods, including stripboard, custom printed circuit boards, plain matrix boards, surface mount boards and wire-wrapping; finishing off, and adding panel labels; getting "problem" projects to work, including simple methods of fault-finding.

In fact everything you need to know in order to get started in this absorbing and creative hobby.

135 pages **Order code BP392** **£5.99**

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The subjects covered include:- Magnetic field detector, Basic Hall effect compass, Hall effect audio isolator, Voice scrambler/descrambler, Bat detector, Bat style echo location, Noise cancelling, LED stroboscope, Infra-red "torch", Electronic breeze detector, Class D power amplifier, Strain gauge amplifier, Super hearing aid.

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The projects include:- Simple audio links, F.M. audio link, P.W.M. audio links, Simple d.c. links, P.W.M. d.c. link, P.W.M. motor speed control, RS232C data links, MIDI link, Loop alarms, R.P.M. meter.

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R. A. Penfold

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LM3909 REPLACEMENT MODULE

The venerable, useful and easy-to-use IC the LM3909 was a popular chip used for flashing LEDs, delivering a tone to a speaker or triggering a triac. Sadly, it has been discontinued – but now it has been reborn in this handy little module! It does everything and more that the first version did.

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EPE EXCLUSIVE

Win a Microchip mTouch AR1000 Development Kit!

EVERYDAY PRACTICAL ELECTRONICS is offering its readers the chance to win one of four mTouch AR1000 Development Kits from Microchip. The kit provides everything designers need to get started using AR1000 resistive controllers and includes the AR1000 development board, a seven-inch four-wire resistive touch screen, a PICkit Serial Analyzer and all the necessary interface cables, as well as a CD containing technical documentation and all the necessary software. The CD also includes an easy-to-use AR1000 configuration utility, which has a graphical user interface (GUI) that enables designers to test all user-configurable options with the AR1000 controllers.

The AR1000 controllers eliminate trial-and-error engineering by providing sophisticated, proprietary touch-screen decoding algorithms that enable applications to receive fully processed, reliable touch coordinates. Combining Microchip's capabilities in microcontroller manufacturing with the recently acquired Hampshire Company's 15+ years of experience designing resistive touch-screen controllers, the AR1000 controllers enable low-risk product development, lower total system cost and shorter time to market for embedded resistive-touch designs. Popular due to its low cost, acceptance of finger, glove or stylus-pen inputs, and overall ease of manufacturing and integration, resistive touch-sensing technology is suitable for applications such as mobile phones, industrial automation, retail point-of-sale, gaming/entertainment, and automobile navigation systems.

The AR1000 controllers provide universal 4-, 5- and 8-wire support, as well as support for SPI, I²C and UART communication interfaces, and are available in 20-pin QFN, SOIC and SSOP packages.

HOW TO ENTER

For your chance to win a Microchip mTouch AR1000 Development Kit, visit **http://www.microchip-comp.com/epe-mTouchAR1000** and enter your details in the online entry form.

CLOSING DATE

The closing date for this offer is **30 June 2010**

WORTH $99.99 (approx. £60.00) EACH


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60
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